Evaluation of policy instruments to internalise externalities in the food system in the European Union

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Evaluation of policy instruments to internalise externalities in the food system in the European Union

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Peer Reviews

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Recommended citations

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Individual reports (in order of appearance)

Each individual report published in Appendix 6.3 is the responsibility of its respective institutional contributors. Each report follows the methodology presented in Section 2 of this report. At the request of SLU's partners, the Swedish report is not included in Appendix 6.3.

Bonnet C., Coinon M., Bouamra-Mechemache, Z., and Goulão, C. (2023). **Policy instruments and related economic mechanisms to internalize externalities: Evidence from the French food system**. INRAE, Toulouse School of Economics, France. FOOD Costing and Internalisation of Externalities for System Transition: FOODcoST.

DiPalma, J., Peschel, A.-O., and Thøgersen, J. (2023). **Policy instruments targeting retailers to internalize externalities at the European Union level**. Aarhus Universitet, Denmark. FOOD Costing and Internalisation of Externalities for System Transition: FOODcoST.

Florencio, J. and Temme HM, E. (2023). **Policy instruments targeting consumers to internalize externalities at the European Union level**. Rijksinstituut voor Volksgezondheid en Milieu, The Netherlands. FOOD Costing and Internalisation of Externalities for System Transition: FOODcoST.

Duque Acevedo, M., and Giagnocavo, C. (2023). **Policy instruments to internalize externalities in Spain, Andalusia, Asturias, Catalonia, and Navarra.** Universidad de Almería, Spain. FOOD Costing and Internalisation of Externalities for System Transition: FOODcoST.

Beyene Chichaibelu, B., and Kornher L. (2023). **Policy instruments to internalize externalities outside the European Union level**. Rheinische Friedrich-Wilhelms-Universität Bonn, Germany. FOOD Costing and Internalisation of Externalities for System Transition: FOODcoST.

Baret, P., Borniotto D., and Courtois, A.-M. (2023). **Policy instruments to internalize externalities along the food chain at the European Union level**. Université Catholique de Louvain, Belgium. FOOD Costing and Internalisation of Externalities for System Transition: FOODcoST.

Jitea, I.-M., and Lacurezeanu, D. (2023). **Policy instruments to internalize externalities in Romania.** Universitatea de Științe Agronomice și Medicină Veterinară, Romania. FOOD Costing and Internalisation of Externalities for System Transition: FOODcoST.

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Table of Abbreviations and Acronyms

Abbreviation / Acronyms	Meaning
AECM	Agri-Environmental-Climate Measures
ANSES	Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail
CAP	Common Agricultural Policy
CFP	Common Fisheries Policy
CS	Case study
EC	European Commission
e.g.	*exempli gratia* (for example)
EPA	Economic Partnership Agreements
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FR	France
FSA	Food Standards Agency
GMO	Genetically modified organism
HRI	Harmonised risk indicators
i.e.	*id est* (that is)
IPM	Integrated Pest Management
MBI	Market-based instrument
MSC	Marine Stewardship Council
NDC	Noncommunicable Diseases
NNI	Neonicotinoids
OECD	Organisation for Economic Co-operation and Development
RO	Romania
SE	Sweden
SP	Spain
SSB	Sugar-Sweetened Beverages
TAC	Total Allowable Catches
VAT	Value Added Tax
WP	Work Package

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Foreword

This report was developed as part of Task 2.1 in WP2 of the FOODcOST project. The drafting of this report was made possible thanks to contributions from different institutions: INRAE (*Institut national de recherche pour l'agriculture, l'alimentation et l'environnement*, France), RIVM (*Rijksinstituut voor Volksgezondheid en Milieu*, The Netherlands), UCLouvain (*Université Catholique de Louvain,* Belgium), SLU (*Sveriges lantbruksuniversitet*, Sweden), UAL (*Universidad de Almería*, Spain), USAMV (*Universitatea de Științe Agronomice și Medicină Veterinară*, Romania), AU-MAPP (*Aarhus Universitet*, Denmark), and UBO (*Rheinische Friedrich-Wilhelms-Universität Bonn*, Germany).

The report attempts to provide an overview of the main public policies and economic instruments aimed at internalizing environmental and social externalities in the food market, implemented in the European Union and in four countries (France, Romania, Spain, and Sweden).

The final report was under the leadership of INRAE and the co-leadership of RIVM and UCLouvain. Each individual report published in Appendix 6.3 is under the responsibility of its respective institutional contributors. At the request of SLU's partners, the Swedish report is not included in the appendix.

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Executive Summary

The role of the food sector in ensuring both human and planetary health has been widely recognized globally, including in the European Union (EU), over the past decades (EPA, 2023; FAO, 2023). However, food and agricultural systems generate environmental, social, health, and economic externalities.

Given the complexity of these systems and their far-reaching impacts, public policy plays a crucial role in shaping their trajectory towards sustainability development (Brundtland, 1987), in line with the 2030 Agenda for Sustainable Development.

This study aims to give an overview of main public policies and economic instruments that the EU and four national governments (France, Romania, Spain, and Sweden) have considered to internalize environmental and social externalities in the food market since 2000. In this project, we define 'internalization' as any policy-induced change in costs and/or final product prices. This report attempts to examine public policies holistically and comprehensively, considering their objectives, illustrating their economic mechanisms, and understanding both their intended and unintended effects. Two broad sets of instruments with the potential to internalize environmental and social externalities are considered:

- *Administrative-based instruments* including public procurement, regulation, and other instruments such as coexistence measures, property rights, liability and compensation schemes, tradable permits and auctions, and quotas.
- *Market-based instruments* including taxes and charges, subsidies, and certification and labelling instruments.

Task 2.1 of the FOODCoST project involves a four-step methodological process. We first collect the main public policies implemented in the EU and in the four countries. Then, based on a literature review, we identify their intended and unintended impacts on environmental, social, health, and economic externalities. We also describe, if possible, the theoretical economic mechanisms of internalization. We further provide the methodological approach and descriptive results from the mapping of public policies

selected in the report, pinpointing evidence gaps and recommending policy improvements in the food sector.

1 Introduction

1.1 Why do we need to improve food and agriculture systems in the EU?

The role of the food sector in ensuring both human and planetary health has been widely recognized globally, including in the European Union (EU), over the past decades (EPA, 2023; FAO, 2023). Food systems have a crucial role in assuring food security, food safety, and healthy nutrition. Securing access for everyone to ample, uncontaminated, and nutritious food is essential (Simelane & Worth, 2020). Amidst this, the EU stands as a leader in the global agri-food trade by exporting agri-food products estimated at €229bn and importing agri-food products at €196bn (Eurostat COMEXT 2023). Historic and geographical ties make the EU a significant trading partner for many low- and middle-income countries, particularly in Africa (Kornher and von Braun 2020).

However, climate change, environmental degradation, biodiversity loss, public health concerns, and increasing socioeconomic disparities have intensified the challenges faced by food and agricultural systems (FAO, 2018). Food and agricultural systems generate environmental, social and health, and economic externalities. Notably, the food and agricultural systems are major contributors of negative environmental externalities, including accounting for 11% of total European global greenhouse gas emissions in carbon dioxide equivalent (European Environment Agency, 2019) and biodiversity loss, largely from land clearing, crop production, and fertilization (Vitousek et al., 1997; Burney et al., 2010). For example, while fertilizers and pesticides have increased crop yields and may have been beneficial for food security, they also present severe environmental and health risks (OECD Environment Directorate 2020; Mamy et al. 2022). Beyond this, whilst the food system plays a role in achieving the objective of alleviating food insecurity by improving food availability, accessibility, and affordability, it also leads to health issues, such as obesity and non-communicable diet-related diseases, and socioeconomic concerns like unfair labor conditions (Meybeck & Gitz, 2017; FAO, 2013). Moreover, the societal effects of the food system also cover other social externalities such as improving rural resilience and livelihoods. Rapid societal transformations, including technological advancements and changing consumer preferences, add layers of complexity, altering the landscape of the EU's agricultural and food systems and

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challenging their resilience. Moreover, the industrialization of modern agriculture has raised challenges for animal health and welfare (Vogeler 2019).

1.2 How does the European Union align its food environment with the sustainability objectives?

Institutional background

Given the complexity of these systems and their far-reaching impacts, public policy plays a crucial role in shaping their trajectory towards sustainability development (Brundtland, 1987) in line with the 2030 Agenda for Sustainable Development.

A fundamental change in the way we produce and consume food in Europe is urgently needed. The EU's ambition, as set out in the Green Deal (2019), will be to make Europe the first continent to achieve net zero greenhouse gas emissions by 2050, compared to 1990 levels, and to protect the natural habitat. In this vein, the EU is actively working towards a transformation of European food systems towards sustainability. The main objective of these strategies is to achieve a balance between environmental, social, and economic concerns in the food market. In particular, the new Green Deal for 2030 and 2050, together with the reform of the Common Agricultural Policy (CAP) for 2021-2027, is currently placing the agricultural sector at the center of European political and social debates. This priority is reflected in the development of several comprehensive strategies, including the Farm-to-Fork Strategy, the Biodiversity Strategy, and the Chemicals Strategy for Sustainability, as well as the EU Food Security Strategy. The Farm-to-Fork Strategy (Figure 1), launched in 2020, is the cornerstone of the EU's vision for a fair, healthy, and environmentally friendly food system. The EU is also engaging its trading partners in adopting a similar approach to limit distortions caused by competition between imported and European products (especially with African countries). Europe also works on closely related policies that do not directly target the food market which include the EU consumer policy, the EU environmental policy and the EU public health policy.

Figure 1: Institutional framework at the EU level[1]

[1] Sources: Illustration drawn by INRAE, based on information from EC (2020a) and copyright-free images.

Economic instruments to internalize externalities in food systems

The FOODCoST project examines the internalization of externalities in the food market. An externality is an unintended side effect – i.e. an effect outside of any transaction - of one economic agent's action on another's utility or production level. More precisely, externalities associated to food and agricultural systems are not *directly* reflected in market prices (Pigou, 1920), and play a significant role in the food value chain. In a well-functioning and perfect market, these costs and benefits should be internalized – that means being directly reflected in the costs of the goods and services we buy (Coase, 1960). The existence of externalities leads to market failures in food systems. In economics, market failures represent situations in which ordinary market coordination does not lead to an efficient (perfectly competitive) equilibrium. In such suboptimal market conditions, policy intervention is often required to ensure that these externalities are properly accounted for (Thøgersen, 2014).

A pressing policy question for the European Commission, as well as national and regional governments, then revolves around the design of policy instruments that incentivize agricultural and industrial practices to foster both productivity growth and sustainability. Additionally, it is important to determine whether there are synergies or trade-offs in terms of externalities induced by these objectives. In their pursuit of a sustainable food environment, these authorities implement a comprehensive strategy using policy instruments to internalize and, therefore, reduce externalities in the food market. This strategy includes several policy instruments aimed at addressing market failures and reflecting environmental and societal costs into market prices. These instruments can be broadly divided into administrative-based and market-based categories. A*dministrative-based instruments* provide a framework of legal regulations targeting various externalities. Due to their straightforward nature and ease of implementation with established institutional frameworks, they are indispensable in the toolkit of EU and local governments. Policies in this category encompass direct measures, such as bans or restrictions on certain inputs. The scope also extends to other policy instruments, including coexistence measures, liability regimes, tradable permits, and quotas. Complementing the administrative instruments, *market-based instruments* (MBI) harness economic incentives to correct market discrepancies. MBIs aim at integrating external costs of production and consumption into market prices using a range of tools, including taxes or subsidies, and certification and labeling schemes. By inducing price adjustments, these instruments induce market condition changes, thus promoting sustainable practices and align the food market with societal and environmental aspirations.

1.3 Objectives of Deliverable 2.1 and methodology

The **objective O2.1 of the FOODcOST project** is *"to review the existing and new potential policy instruments for a better internalization of externalities in the food and agricultural systems."* In other words, Task 2.1 aims at shedding light on the complex landscape of policy tools enacted in the European Union and aimed at addressing these issues by securing or facilitating the internalization of externalities along the food value chain. In doing so, the report provides valuable insights for policymakers and stakeholders on how public policies can facilitate the transition to more sustainable food systems, and contribute to a better health, conscious consumption patterns, environmental and biodiversity conservation, and fair economic conditions.

The review was conducted by constructing an overall conceptual approach, which is implemented via this report. As outlined in Figure 2, Task 2.1 of the FOODCoST project is a four-step process. In step 1, the main measures in the European Union, and France, Romania, Spain and some of its Autonomous Communities, and Sweden, were inventoried. In step 2, we review the literature on the effectiveness of each policy selected. Then, we identify the theoretical economic pathways via which agricultural and food policies may impact environmental, social and health, and economical externalities. We extract the main results from the mapping and impact literature in step 3 and provide two syntheses at the producer and consumer levels, respectively. In step 4, we identify new ideas for improving public policies in the food sector.

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Figure 2: Steps of WP2.1 of the FOODCoST project

1.4 Structure of the report

The structure of this report is as follows:

- Section 2 presents the methodology used to review public policies in the food sector at the EU, national, and regional levels.
- In Section 3, we synthetize the review of public policies, the mechanisms of each instrument, and the impact evaluation of these policies based on existing literature in economics and interdisciplinary research.
- Finally, Section 4 suggests new policy ideas that could be implemented to better internalize externalities in the food sector. These recommendations will be examined more closely in WP4 on the *Mobilization and mutual learning activities with external stakeholders* (i.e. policy makers) and tested in *specific case studies on internalization of externalities* in WP5.

2 Method to review policy instruments

2.1 Introduction

This section details the **methodology** used for Task 2.1 of the FOODCoST project. The objective of this task is to map, describe, and assess public policies that promote or facilitate the internalization of externalities within food value chains in the EU, both at national and regional levels. For our purposes, we define 'internalization' as any policy-induced change in costs and/or final product prices. This approach helps to examine public policies holistically and comprehensively, considering their intent, illustrating their economic mechanisms, and understanding both their intended and unintended effects.

The output of the literature review is a systematic evaluation of public policies that contribute to the internalization of externalities in the food system at the European Union level, and in 4 countries: France, Romania, Sweden, and Spain, including selected policies from four Spanish *Comunidades Autónomas* (Andalusia, Asturias, Catalonia, and Navarre). Four individual reports are produced to evaluate public policies at the EU level focusing each on different economic agents along the food chain including producers, processors, retailers, and consumers. The four country-level analyzes are also reported separately, providing quantitative and qualitative information needed to understand the context and impact of the main policies implemented since 2000 along the entire food system. More precisely, we first inventoried the measures aimed at internalizing the externalities, and changing main agents' behaviors at the EU, national, and regional levels given the selection criteria. Second, we evaluated their effectiveness and conducted a review of academic literature to illustrate their impacts on environmental, social, and economic externalities. The subsequent sections of this report present our findings, providing a resource for policymakers, stakeholders, and researchers interested in this critical area of public policy.

The remainder of this section is organized as follows. Section 2.2 presents the expert panel involved in Task 2.1. Section 2.3 lays down the procedure for collecting the main

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public policies. This section includes a description of the inclusion and exclusion criteria, as well as the resulting list of topics and thematic areas studied in this subtask. Section 2.4 provides an overview of the literature review search strategy and discusses any risk bias regarding the mapping and evaluation of public policies. Section 2.5 presents the descriptive analysis of the compiled policy database, while Section 2.6 discusses the procedure for identifying new ideas.

2.2 The expert panel

The Task 2.1 expert panel consists of 19 independent experts, specialized in economics, agronomy, food sciences, management, and psychology, and working in academia. These experts belongs to 8 different research institutions: INRAE (*Institut national de recherche pour l'agriculture, l'alimentation et l'environnement*, France), RIVM (*Rijksinstituut voor Volksgezondheid en Milieu*, The Netherlands), UCLouvain (*Université Catholique de Louvain,* Belgium), SLU (*Sveriges lantbruksuniversitet*, Sweden), UAL (*Universidad de Almería*, Spain), USAMV (*Universitatea de Științe Agronomice și Medicină Veterinară*, Romania), AU-MAPP (*Aarhus Universitet*, Denmark), and UBO (*Rheinische Friedrich-Wilhelms-Universität Bonn*, Germany).

All experts agreed to participate in the panel as outlined in the FOODCoST Grant Agreement, either focusing on a specific economic agent at the European level or conducting a country-specific analysis.

Figure 3 lists the names of the contributors who consented to participate in Task 2.1, along with their respective institutions, research expertise, and the specific scope (economic agents and geographical scope) they are working on for this task, respectively.

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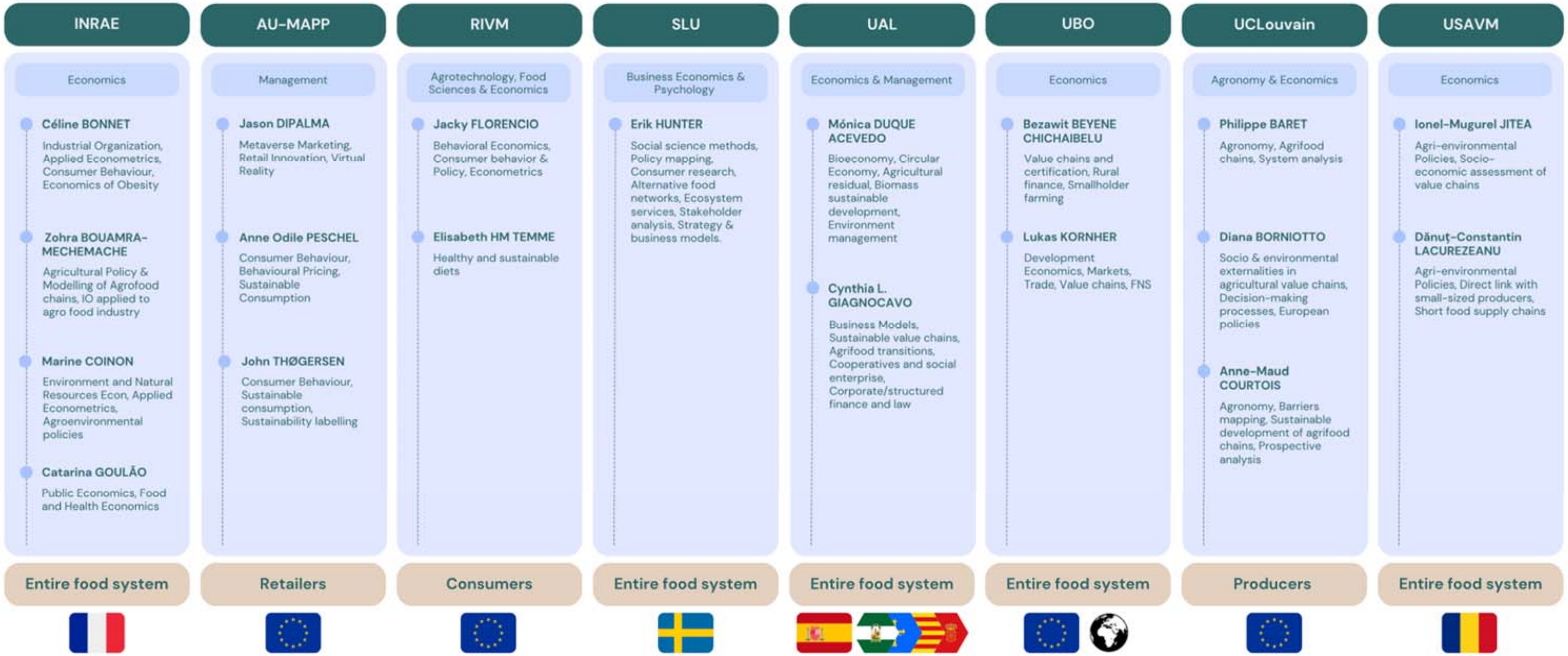


Figure 3: Expert panel, expertise, and Task 2.1 scope

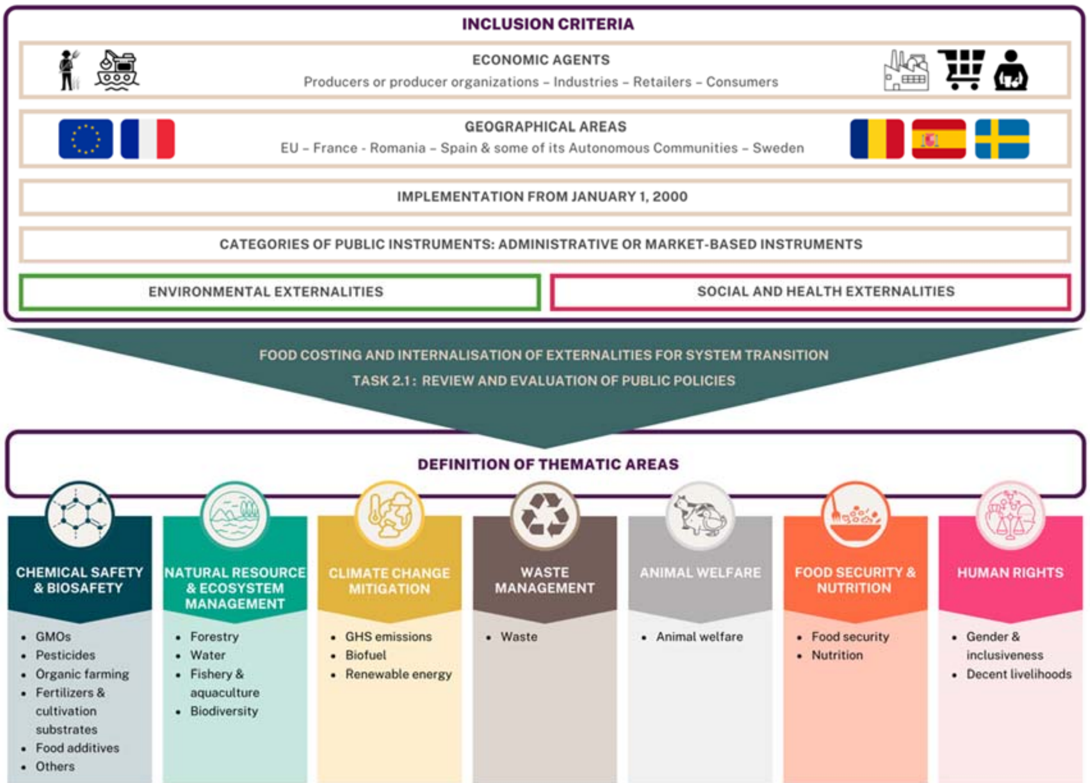
2.3 Step 1: Collection of public policies at the EU, national and regional levels

The objective is to compile a comprehensive list of policies (referred to as "mapping", hereafter) that aim to internalize externalities at the EU, national, and regional levels.

First, we defined inclusion and exclusion criteria for the public policy search. Figure 4 displays the six criteria used for selecting public policies. These inclusion and exclusion criteria were designed to standardize and streamline the analysis of policies at both EU and national levels. This strategy is essential to ensure that the data collected is reliable, valid, and comparable across different geographical contexts.

The collection of public policies was achieved by encompassing four different sources. Existing materials (or databases) that focus on specific food policies, such as NOURISHING, SCAR, and the WHO global database, were explored to identify policies that are already available in these repositories. In addition, we rely on the websites of EU member state governments and the European Commission.

Figure 4: Methodology for selecting public policies



2.3.1 Inclusion and exclusion criteria

2.3.1.1 Economic agents

The primary target is the reference level for the policy mapping and evaluation. Modern food systems are interconnected and constitute complex global networks of production, processing, manufacturing, supply, retail, services, and consumption. Agriculture is the main food production sector, complemented by fisheries and aquaculture. In this report, we do not consider pre-production primary targets such as input distributors.

2.3.1.2 Geographical area

The report aims to analyze policies with internalized externalities at the EU, national, and regional levels. Each institution that is part of Task 2.1 is responsible for mapping and evaluating a specific geographical scope as agreed upon in the Grant Agreement. The leader reviews at the EU level (UCLouvain and RIVM) and each partner reviews policies for its country: France (INRAE), Spain (national and regional levels, UAL), Romania (USAMV), Sweden (SLU). AU-MAPP oversees a specific analysis of policies that directly affect retailers at the European level. Finally, UBO reviews a selected number of EU policies that have implications for developing countries.

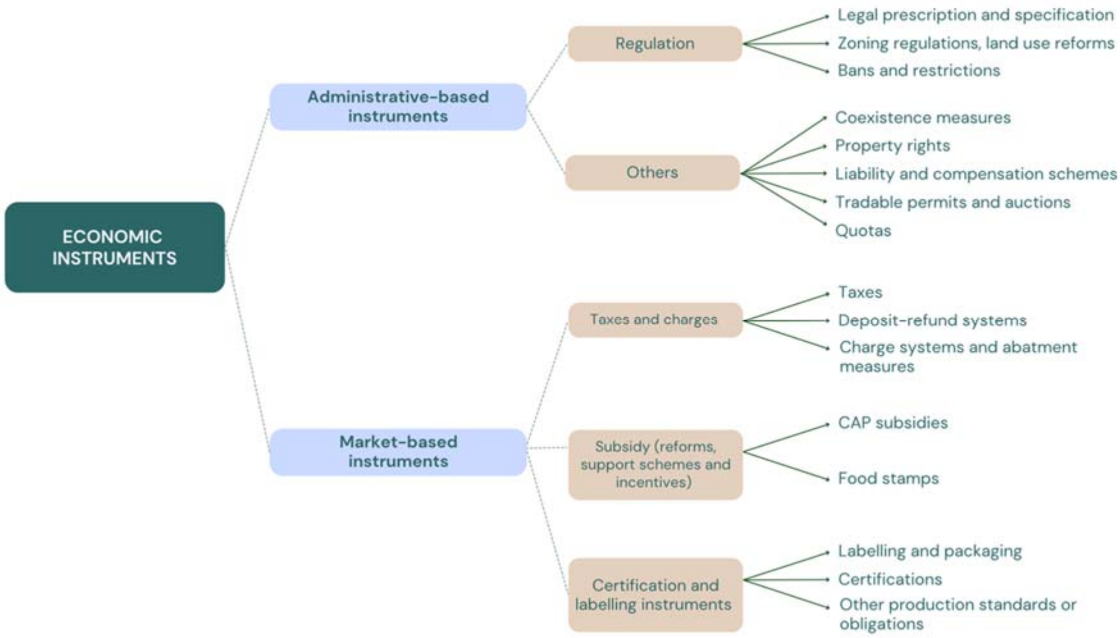
2.3.1.3 Timing

The timing factor is critical in policy analysis. To ensure tractability, we include only public policies that were implemented starting on January 1, 2000. The rationale for this timeline is to enable us to assess the evolution of policies and their impact on internalizing externalities in the short and long-term over the past two decades.

2.3.1.4 Policy design

We review the public policies that aim to internalize externalities in the food sector, with the overarching objective of maximizing economic agents' contribution to society's welfare. In this report, we include public policies that *directly change production costs (through input prices and/or quantities) and/or prices for the final consumer goods.* Our analysis excludes policies that generate welfare gains due to non-price effects only.

Figure 5: List of economic instruments



We encompass a range of policy instruments used to internalize externalities, as shown in Figure 5, including:

- **Administrative-based instruments:**

An administrative policy is a set of legal regulations that can be used against any kind of externalities or market failures. They have the advantage of being easy to implement in a country with functional institutions (in terms of justice, administration, and political legitimacy). This involves evaluating the effectiveness of regulatory measures implemented by governments to enforce sustainable practices and ensure compliance with environmental and social regulations within the food sector.

These policies are prescriptive and offer the private sector limited flexibility in achieving their goals:

- Regulations, such as bans or restrictions, that aim at prohibiting a specific or a group of inputs, legal prescription and specification, and zoning regulations and land use reforms.

- Other administrative-based instruments such as coexistence measures, property rights, liability regimes and compensation schemes, tradable permits, auctions, and quotas.

- **Market-based instruments:**

Market-based instruments (MBIs) seek to address the market failure of externalities by incorporating the external cost of production or consumption activities. In other words, they use markets, price, and other economic variables to *provide incentives* or *improve signals* for producers and consumers to reduce or eliminate negative externalities (or alternatively, increase positive externalities).

We characterize MBIs based on their aim and functioning. The review assesses the impact of market-based instruments, such as:

- Taxes and charges are the most widely used MBIs. They are designed to change prices and thus the behavior of producers and consumers, as well as raise revenues. Charges are designed to cover partly or fully the costs of environmental services and abatement measures.
- Subsidies, subsidy reform, support schemes and incentives: The OECD (1998) broadly defines a subsidy as "*any measure that keeps prices for consumers below market levels or for producers above market levels, or that reduces costs for consumers and producers*." Subsidies and incentives are mainly designed to stimulate the development of new technologies, create new markets for goods and services, including technologies, encourage changes in consumer behavior, and provide temporary support to achieve higher levels of environmental and societal protection.
- Certification and labeling instruments are employed to address asymmetrical information problems or a lack of rationality in the market. Although they may not have been initially designed to internalize externalities, they can result in higher prices that signal changes in market conditions to all agents because of vertical differentiation.

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The study does not include behavioral instruments (e.g., nudges), information campaigns through education, training, and national programs, that encourage sustainable choices without directly impacting prices and/or costs.

2.3.1.5 Sustainability dimensions

The scope of our analysis in terms of externalities for sustainability dimensions is based on Work Package 1 *"Methodologies and data to calculate external costs and benefits"* of the FOODCoST project. For tractability reasons, we restrict the scope to the mapping of public policies that aim to internalize environmental or social externalities, but not economic externalities. After selecting public policies based on this criterion, we assess their *direct* and *indirect* impacts on three categories of externalities: environmental, social and health, and economic (see Table 2).

2.3.2 Definition of thematic areas

We define *seven thematic areas* related to specific key topics (Figure 4). By examining these thematic areas comprehensively, the report aims to offer valuable insights into sustainable practices and policies that promote ecological well-being, social equity, and human prosperity. Under the domain of *chemical safety and biosafety*, the report delves into the realms of GMOs, pesticides, organic farming and integrated pest management, fertilizers, cultivation substrates, and food additives. *Climate change mitigation* constitutes another crucial focus, encompassing greenhouse gas (GHG) emissions, biofuels, and renewable energy sources. The report further explores *natural resource and ecosystem management*, including aspects of forestry, water management, fishery, aquaculture, and biodiversity preservation. Additionally, *human rights aspects* are addressed, with particular emphasis on gender and inclusiveness, as well as the promotion of decent livelihoods. *Animal welfare* and as well as *food security and nutrition* hold a distinct place in this analysis. Waste management is another significant aspect included in the report, addressing efficient strategies for waste handling and sustainable disposal.

Table 1: List of externalities defined in Work Package 1

GROUP OF EXTERNALITIES	Midpoint categories	Midpoints
ENVIRONMENTAL EXTERNALITIES	**Climate change**	Climate change
	Acidification & eutrophication	Acidification; eutrophication
	Particulate matter	Particulate matter
	Water stress	Water use; Temporary costs of drought and excess water
	Land use and land transformation	Land use; Land transformation; Indirect land transformation; Soil depletion
	Direct effects on biodiversity and ecosystems	Direct effects on biodiversity and ecosystems
	Toxicity	Ecotoxicity and human toxicity
	Non-renewable resource depletion	Resource (mineral and metals; fossils)
	Ozone and radiation	Ozone depletion; Photochemical ozone formation, human health; Ionizing radiation, human health
	Noise, smell, and visual disturbance	Noise, smell, and visual disturbance
SOCIAL EXTERNALITIES	**Labor right and conditions**	Fair wage/Living Income; Excessive working hours; Child and forced labor; Discrimination; Occupational health and safety
	Local community rights and wellbeing	Respect of indigenous rights; Community engagement; Education; Social cohesion; Power of women; Poverty; Safe and healthy living conditions; Secure living conditions; Access to material and immaterial resources; Delocation and migration; Cultural heritage
	Equity	Income and wealth distribution; Poverty; Hunger
	Infectious diseases	Zoonoses; Infectious plant and animal diseases; Antibiotics resistance
	Food safety	Food safety risks; Hygiene
	Health effects of diets	Health effects of diets
	Food security	Food security (incl. vulnerability and self-sufficiency)
	Consumer rights	Transparency; Privacy
	Animal welfare	Animal welfare
ECONOMIC EXTERNALITIES	**Income transfers**	Income transfers
	Infrastructure spillovers	Infrastructure spillovers
	Knowledge capital spillovers	Innovation, knowledge
	Human capital spillovers	Human capital
	Network effects	Network effects
	Effects on market structure	Effects on market structure
	Effects on employment	Effects on labor supply; Effects on labor demand
	Effects on transaction costs	Effects on transaction costs

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2.4 Step 2: Policy evaluation

2.4.1 Literature review search strategy

The search strategy is adapted from the previous review conducted by Brondi et al. (2019). Given the broad range of interdisciplinary specialties involved in Task 2.1 (see Figure 3 for the institutions involved and their main disciplines), we initially established a common glossary of definitions, which can be found in Appendix 6.1. The review was approached by conducting online searches, applying search strings, via Web of Science, Google Scholar, and Scopus. The Google database has been also used by some teams to make their review more exhaustive. Searches were conducted between December 2022 and July 2023.

No language restrictions were applied during the database searches and literature review. This review mainly covers English-language and country-specific publications.

Several types of studies are included in this report. These sources include peer-reviewed (academic) literature, policy reports, data from reputable sources, stakeholder interviews, and case studies.

All **quantitative and qualitative academic studies** that examine subjects related to the specific public policy, instrument and its respective impacts on externalities were considered eligible. The following types of quantitative studies were considered for inclusion: impact analysis, theses, systematic reviews and meta-analyses, prospective and retrospective cohort studies, cross-sectional studies, surveys, online experiments, lab experiments, field studies, and case-control studies. These sources are crucial for understanding the theoretical and empirical contexts of the policies under review. Qualitative studies are also included in this report, such as focus groups.

In addition, certain **grey literature** (for example policy evaluations published by governments and research institutions, legislative texts, and policy guidelines), were also used, especially to understand the specific policies' implementation and intent.

When it was not possible to access a relevant article, but an abstract was available, we relied on the main results explained in the abstract. The few cases for which neither abstract nor full available article data extraction was possible have not been included.

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Finally, while the review primarily focuses on economic literature, it is not limited to this domain, and various sources from other disciplines such as agronomy, ecology, and psychology, are incorporated to ensure comprehensive coverage.

We differentiate mechanisms for each relevant economic agent along the food value chain, the impact of each instrument on consumption behavior, and their effect on both targeted and non-targeted externalities. From a policy-making perspective, understanding of the legal background as well as consumption behavior can be particularly important, especially when there is a lack of literature on the subject.

Each individual report then outlines the actual and potential effectiveness of public policies and instruments to facilitate the internalization of externalities. The content of each section was defined by INRAE (Task 2.1 leader) and includes the following aspects: a) policy background in which these policies are implemented, giving details about the legal instrument and policy framework; b) mechanisms of the instrument for internalization such as the impact on production costs, pass-through to price, attention and awareness of the instrument; c) effect on consumption, and d) effects on both targeted and non-targeted externalities. They also explain the methods used and approach adopted to managing these impacts.

Each institution was responsible for selecting the public policies as well as the literature following the methodology proposed by the leader INRAE and validated by all partners.

2.4.2 Risk of bias assessment

Evidence selection bias happens when a review misses out on some available data on a topic. In Task 2.1, individual mapping and studies might exhibit biases in their results or conclusions due to various factors, such as effort (person-months) allocated to Task 2.1, academic background, and expertise. Implementing this risk of bias assessment can be challenging due to the number of policies to evaluate and time limitations. We primarily depend on each partner's specialized assessment to ensure the best representation of policy diversity across the European Union and specific countries and regions. The resulting mappings and individual reports are heterogeneous across partners. Consecutive reviews by INRAE and bilateral meetings with Task 2.1 partners along the process are used to address this issue as much as possible.

2.5 Step 3: Descriptive analysis

2.5.1 Data extraction

Data was collected from included studies using a customized and standardized data form. The developed form proposed by INRAE was initially piloted with a small number of included public policies before undergoing two revisions to extract data from all studies. It was approved by all partners. The policy mapping and evaluation database provides a standardized methodology for mapping and reviewing public policies that internalize positive or negative externalities in the food sector within the European Union. Each team completed an Excel file based on its specific scope (outside the European Union, the EU, one country, or one region) and was responsible for its own content. Table 2 provides more details about the structure and content of the final database with different entries by sections (in bold). The database contains three parts: a) the description of the policy, b) policy instruments, and c) evaluation of the policy, if possible. Each part contains different columns, which are listed in the table. Appendix 6.2 provides the list of public policies covered and compiled in the final database.

Table 2: Structure of the policy mapping and evaluation database

POLICY REFERENCE	Name of the policy	Type of legal instruments	Issuing entity or institution	Date of promulgation of the policy	Date of effect of the policy
	Description of the policy context and specific objectives of the policy.	Geography: where the policy applies applies	Define project activities, dependencies, and sequencing	Ultimate beneficiaries: Economic agents that are directly affected by the policy	Governance – partnerships between the public and private sectors, and promoting involvement of key food chain actors
	If any, type of products targeted by the policy.	Official reference	List names and reference of other policies stated or mentioned in the policy document	Evolution of the policy	Voluntary or Compulsory
	Policy type: Administrative vs. market-based policy				
POLICY INSTRUMENTS	Policy instrument	Rational: which externality group is mainly targeted by the policy instrument	Issuing entity or institution	Rational: why does this specific policy instrument have been implemented? What is the context?	Primary targets
	Ultimate beneficiaries				
POLICY EVALUATION	Rational: Main externality group that is mainly targeted by the policy	Rational: why does this specific policy instrument have been implemented? What is the context?			

Beyond its primary objective of summarizing the legal framework and impact literature, this database has allowed to harmonize the methodology progressively. Like the selection process, the extraction of all data for descriptive statistics was performed by INRAE. The Task 2.1 leader conducted an independent review of the assigned records. After cross-checking, any disagreements were discussed between INRAE and the respective team when possible and needed.

2.5.2 Descriptive results

This section presents a descriptive statistic on the public policies implemented in the European Union and in four specific countries and included in Task 2.1. To our knowledge, there is no study covering such many public policies while determining all these characteristics and offering a discussion on the mechanisms and their effects. This analysis sheds light on key policy trends and patterns in the food sector.

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Table 3 provides an overview of the thematic areas covered in Task 2.1. The final policy mapping database comprises a total of 171 policies, a majority of which, 60.82% (104) are national policies, while the remaining 39.18% (67) are EU level policies. This may reflect the important role that national governments continue to play in the design and implementation of food policy, even in the context of a highly integrated market such as the EU. In addition, this report highlights the role of sub-national entities with a specific study on public policies that have been implemented in four Spanish Autonomous Communities (Andalusia, Asturias, Catalonia, Navarre).

In terms of the type of legal instruments used, the data reveals that decrees, orders, and laws predominate at the national level, while Regulations and Directives are primarily used at the EU level (Figure 7). Moreover, Figure 8 shows the distribution of targeted externalities. Most of the policies target social aspects (67%) followed by environmental aspects (33%). The proportion is similar in both the EU and national levels. Given the increasing global concern over environmental sustainability, especially in the context of the food sector, a primary focus on environmental policies may be necessary.

The descriptive analysis reveals a complex landscape of public policies at national and EU level, with a focus on administrative measures and social issues. The study highlights the need for further research to deepen our understanding of the impact of policies and the potential for more integrated, market-oriented, and environment-focused policies. This research provides a valuable basis for future policy analysis and development in the food sector in the EU and in the countries studied. It underscores the importance of continuously reassessing policies and mechanisms to ensure that they effectively address society's evolving needs and challenges.

While this review provides a thorough overview and evaluation of public policies at the EU, national and regional levels, it is not exhaustive and does not allow for a gap analysis of the literature.

Table 3: Overview of the thematic areas addressed in Task 2.1

	MAPP	RIVM	UBO	UC Louvain	INRAE	SLU	UAL	USAVM
Geographical level								
	EU				FR	SE	SP	RO
Chemical safety & biosafety								
GMOs				x	x			x
Pesticides				x	x		x	
Organic farming & Integrated production	x						x	x
Fertilizers & cultivation substrates				x			x	
Food additives		x						
Climate change mitigation								
GHG emissions & Biofuels			x				x	
Renewable energy (solar)							x	
Natural resource & ecosystem management								
Forestry			x					
Water								
Fishery & aquaculture				x	x		x	
Biodiversity					x			
Human rights, gender & inclusiveness, and decente livelihoods			x					
Animal health & welfare				x		x	x	
Food security & nutrition								
Food safety	x	x	x				x	x
Food security							x	x
Nutrition		x			x	x	x	
Waste							x	
Others								
Economic support to agricultural sector (CAP)			x	x				
Fair income			x					
Quality schemes								x

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Figure 6: Policy type

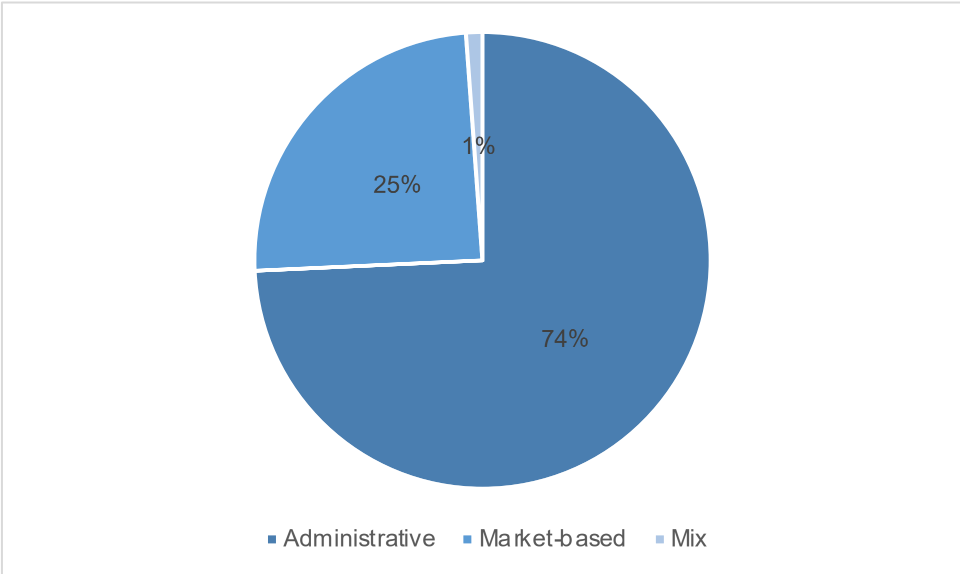


Figure 7: Type of legal instruments

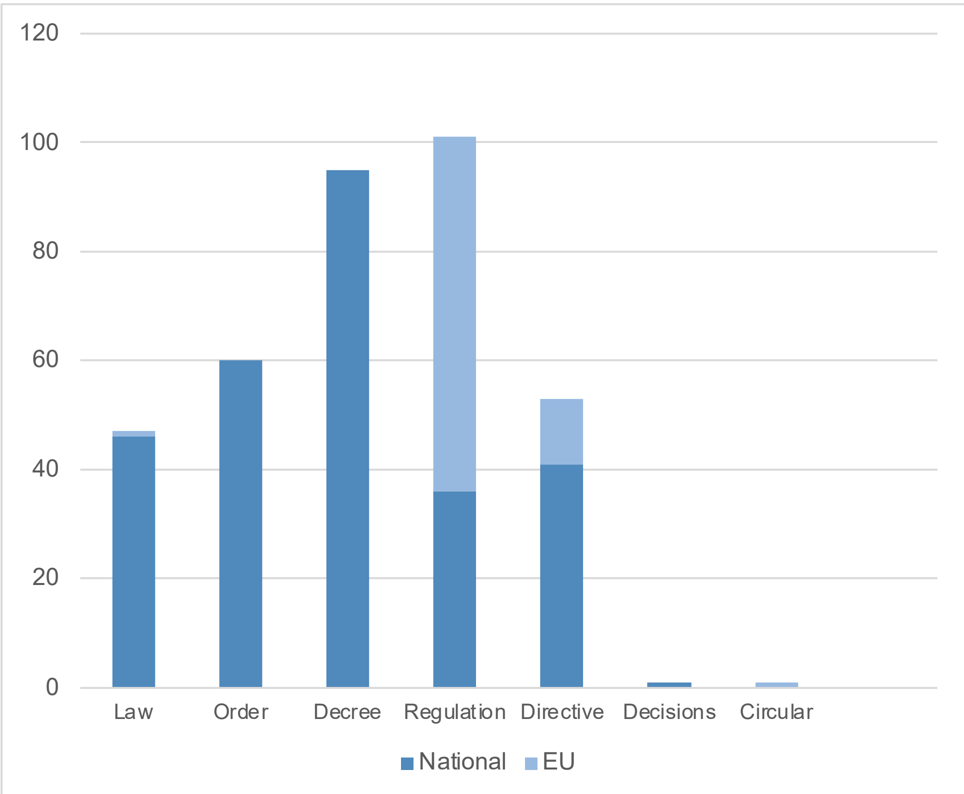
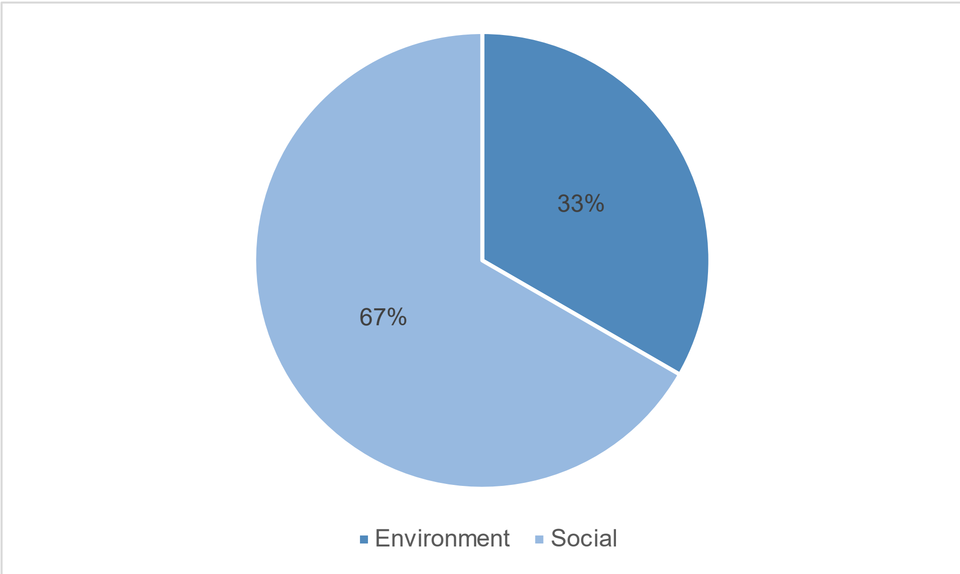


Figure 8: Targeted externalities



2.6 Step 4: Identify new ideas to create a sustainable food environment at the EU and national levels

Step 4 delves into the formulation of new ideas. The comprehensive review serves to discern potential policy instruments that should be implemented. We formulate a set of new ideas to create a better sustainable food environment at the EU and national levels. A final list of eight new ideas is proposed based on the assessment of economic mechanisms and the most debated issues related to the impacts of food system activities.

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3 Policy instruments along the food chain

3.1 Introduction

Policies are designed to influence and shape each stage and help internalize externalities along the food chain. Navigating the complex array of policies related to food systems, we identify a clear dichotomy in strategies: those that affect economic agents in the early stages of the **food supply chain** (i.e. producers and the food industry), and those that target consumers directly, commonly known as **"demand-side policies"**. This chapter delves into both categories, examining **administrative and market-based instruments**. For each instrument, we address it specifically by defining its objective, the economic mechanisms involved, and its effectiveness in internalizing externalities within the food system.

Policies affecting upstream actors in the food system

The next section 3.2 shifts the focus to policies and policy instruments that influence actors operating upstream in the food supply chain such as farmers and the food industry. These interventions, ranging from production to processing stages, are critical in shaping the overall trajectory of the food system and ensuring that it is aligned with broader societal and environmental goals. The tools of choice for policymakers working in this area are mainly regulatory instruments, but also include some market-based instruments.

Demand-side policy interventions

Demand-side interventions have a clear role to play in shaping consumer behavior, either through taxation schemes or nudging through incentives and promotions. The main purpose of these strategies is to encourage consumers to make responsible and informed choices about their dietary habits. Section 3.3 focuses on demand-side policies that have a direct impact on the cost or final price of food products. This includes market-based and administrative instruments at both EU and national levels.

3.2 Policy instruments to internalize food system externalities affecting producers

3.2.1 Administrative-based instruments

3.2.1.1 Ban on inputs

The European Union has a long history of implementing regulations to protect the environment, ensure health and food safety, and safeguard public health. These regulations **include protocols for identifying and assessing the risks** associated with specific substances or technologies. Risk assessment in the food system, particularly for the pre-approval of substances, is a structured process for evaluating the health risks associated with the consumption of certain foods or ingredients. These regulations aim to harmonize the EU market and minimize adverse effects on public health and the environment. Risk assessment involves the identification of potential hazards in substances such as chemicals, microbes, or physical agents. This is followed by hazard characterization, which determines the nature and severity of health effects and often examines the dose-response relationship. The subsequent exposure assessment phase estimates the uptake of the substance, considering consumption rates and specific populations such as children or pregnant women. The final step, risk characterization, integrates all data to estimate overall health risks and inform risk management decisions. The agro-industry must comply with these regulations to ensure that their products meet stringent standards. If a substance or technology is found to have potential adverse health or environmental effects, it may be restricted or banned after risk assessment.

3.2.1.1.1 Definition

In economic terms, a **ban or restriction** is a **prohibition** of producing, selling, or consuming a specific input, good or service in a particular jurisdiction. Governments or regulatory bodies use it as a regulatory tool to restrict or eliminate certain activities or transactions. In particular, the establishment of stringent rules often involves setting restrictions to protect the EU market from unsustainable or hazardous products.

Box 1: Bans at the EU and country levels

Ban on neonicotinoids

In 2018, the European Union voted to ban three of the major outdoor uses of neonicotinoid (NNI) insecticides (clothianidin, imidacloprid and thiamethoxam) based on environmental concerns, particularly with respect to pollinator population and non-target organisms (Bomgardner, 2013; Woodcock et al., 2017; Butler, 2018) due to their persistent toxicity and environmental dispersion (European Food Safety Authority, 2018).

The French case

France has been at the forefront in Europe when it comes to implementing strict measures on pesticides. The French government first banned the use of imidacloprid on sunflowers in 1999 and on corn in 2004. As part of the Law for the Reconquest of Biodiversity, the French Agency for Food, Environmental, and Occupational Health & Safety (ANSES) assessed the risks and benefits of alternative methods for protecting plants and controlling pests in France, including non-chemical options and alternatives to neonicotinoid-containing products (Ballot et al., 2018). As of September 1, 2018, France went further than EU legislation by banning five NNIs for all uses (Ministère de la Transition Écologique, 2018), including the three active substances regulated at the EU level, and thiacloprid and acetamiprid, on September 1, 2018. Exemptions were allowed until July 1, 2020. Derogations were granted in 2021 and 2022 due to a virus outbreak, allowing the use of NNIs on beets. However, the Conseil d'Etat revoked these derogations in November 2022.

Ban on GMOs

The European Commission is monitoring advances in biotechnology in line with the *European Green Deal* and the *Farm-to-Fork Strategy*. EU legislation on GMOs aims to protect human and animal health, the environment and to ensure a functioning internal market. Directive 2001/18/EC requires standardized procedures for the release of GMOs, excluding techniques such as mutagenesis. Regulation (EC) No 1829/2003 allows Member States to decide on the cultivation of GMOs, considering consumer concerns and regional differences.

Comparison between France and Spain

The only GM maize approved for cultivation in the EU is MON810, which is mainly grown in Spain (96%) and the rest in Portugal. France, along with Spain, began growing GMOs in 1998, focusing on three transgenic maize varieties. However, in 2008, due to environmental concerns such as insect resistance and impact on biodiversity, France suspended the cultivation of MON810 corn, using European legislation to support its stance. Despite successive moratoria, challenges, and legal disputes with the seed industry, France decided to maintain the MON810 ban in 2015, using the "opt-out" provision agreed upon by all EU member states. However, France allows the import and marketing of GM food or feed that complies with European regulations (i.e. EU approval and labeling standards). Several EU countries have also banned GMOs, including Germany, Austria, Greece, Hungary, the Netherlands, Latvia, Lithuania, Luxembourg, Bulgaria, Poland, Denmark, Malta, Slovenia, Italy, and Croatia.

3.2.1.1.2 Economic mechanisms of the instrument

Ban on agricultural inputs (e.g. pesticides such as neonicotinoids) or technologies (e.g. GMOs) can affect production costs. While the literature shows mixed results, the economic impact is first influenced by **changes in crop yield.** Indeed, neonicotinoids and GMOs, aimed at boosting crop yields, have become controversial due to potential yield, profitability, and market shifts (Bonmatin et al., 2015), while having potential adverse effects on the environment, biodiversity, and public health. However, in both cases, their actual benefits are debated. In the case of neonicotinoids, for example, U.S. studies suggest that their prophylactic use does not consistently improve yields (Stevens and Jenkins, 2014; Budge et al., 2015; Douglas and Tooker, 2015). The effect of a ban on production costs mainly varies by crop and region. Moreover, every ban on pesticides has sparked discussions on **substitution from plant protection products to chemical or non-chemical alternatives**, and their effects on productivity because they might be more costly. On one hand, chemical alternatives might be less efficient and potentially more harmful. On the other hand, non-chemical alternatives, like biocontrol, can be effective but might require significant farm adjustments. The ban could also push farmers toward less pest-vulnerable crops or advanced technologies. Banning some pesticides might also alter **seed treatment prices and practices**, potentially raising costs due to expensive substitutes.

Banning an input such as a specific pesticide might however raise **pest resistance challenges**. Pests can develop resistance, especially in monocultures, creating super pests resistant to multiple pesticides. The reduced variety of insecticides post-ban could further enhance the risk of cross-resistance.

Because of increased production costs and potentially reduced yields, a ban could also *indirectly* lead to **higher consumer prices** (Bonmatin et al., 2015). However, there is no direct evidence currently linking any ban to consumer price changes. The extent to which these increased costs are passed on to consumers depends on the elasticity of demand for the agricultural product, market competitiveness, and consumer perceptions. If demand is inelastic, producers may be able to pass the costs on to consumers without much impact on sales volumes (Böcker and Finger, 2017). In contrast, if demand is elastic, significant price increases could significantly reduce demand and discourage producers from passing on increased costs to consumers. In highly competitive markets, producers may absorb the additional costs to maintain their market position, potentially limiting price increases for consumers (Seaton and Waterson, 2012). If consumers recognize and support the environmental benefits of the banned products or substances, they may be willing to bear higher costs.

A ban can also have an indirect impact on **public awareness and acceptance of sustainability issues** related to the food system. A ban can indeed shift consumer preferences towards non-banned products, with many willing to pay a premium. This shift is driven by concerns about the benefits, safety, and broader impacts of banned inputs. Therefore, even if production costs increase because of the ban, the increased willingness of consumers to pay for unbanned products may compensate farmers for these additional costs.

3.2.1.1.3 Policy impacts on externalities

Bans and restrictions, when effectively implemented, are considered effective, offering a higher level of protection for the environment, consumers' health, and the market conditions itself. However, the impacts and potential consequences of a ban, such as that on neonicotinoids and GMOs, are multifaceted and can lead to different outcomes depending on the context. They indeed vary depending on factors such as crop type, pest prevalence, and available alternative pest management methods, leading to different outcomes in different agricultural contexts (Bonmatin, 2017; Simon-Delso, 2014). The long-term environmental impacts of bans also depend on how pest management strategies are adapted (Lechenet et al., 2017). Although removing harmful chemicals may promote healthier ecosystems and sustainable agriculture (Bonmatin, 2017), these benefits may be offset if chemical alternatives with their own detrimental impacts are used (Kathage et al., 2018; Bass and Field, 2018).

3.2.1.2 Legal prescriptions

3.2.1.2.1 Definition

At the producer level, **legal prescriptions** generally refer to **rules, regulations, and specific mandates established by governing bodies that farmers must comply with**. In economics, legal prescriptions can be seen as external constraints on a producer's production function, potentially influencing the cost of production, the types of products produced, and the methods of production chosen. This could include anything from sanitation standards in food processing facilities to the allowable use of certain pesticides in agriculture. Producers must comply with these regulations or face potential penalties, which can include fines, etc. To foster positive change in the agri-food value chain, the EU and Member States have adopted several policies that prescribe specific measures to reduce the negative social and environmental externalities.

Box 2: Direct prescriptions at the EU level

At the European level, direct prescriptions include specific conditions for the transport of live animals (Regulation (EC) No 1/2005); the Landing Obligation and technical measures under the Common Fishery Policy, such as minimum fish sizes and fishing gear to be used (Regulations (EU) No 1380/2013 and (EU) 2019/1241); measures to reduce nitrate pollution from agricultural sources under the Nitrate Directive (Directive 91/676/EEC); the obligation for EU member states to develop and implement national action plans to promote the sustainable use of pesticides, reduce risks to human health and the environment, and minimize the overall impact of pesticide use under the Sustainable Use of Pesticides Directive (Directive 2009/128/EC); the obligation to take specific actions to achieve the targeted share of renewable energy in the overall energy mix under the Renewable Energy Directives; or mandatory measures in Member States such as Spain to reduce total nitrogen excreted and ammonia emissions from livestock farms.

3.2.1.2.2 Economic mechanisms of the instrument

It is commonly acknowledged that legal prescriptions have economic implications for farmers, both in terms of costs and potential benefits. Indeed, compliance can result in **direct costs**, such as **requiring and purchasing chemical or non-chemical alternatives to harmful pesticides** or **making capital investments** in new equipment, material, or **investing in human capital** (Giner Santonja et al., 2017). While these regulations can increase operating costs, they can also drive farmers to adopt more efficient production methods, such as drip irrigation due to water use restrictions. Complying with these prescriptions also often requires **undergoing inspections and certifications**, which can be time consuming and costly. In the aquaculture sector, for instance, the application of strict environmental regulations has sometimes been associated with a reduced growth in the sector (Guillen et al., 2019; Abate et al., 2016).

On the other hand, the promotion of environmentally friendly practices (under the legal prescription framework) in certain contexts has been linked to economic benefits for producers through, for instance, more efficient farming practices that could lead to lower fertilizer costs and higher yields. Compliance can also allow farmers to differentiate their products and charge higher prices based on consumer preferences for sustainable goods. Compliance also reduces legal risks and liabilities for farmers. To alleviate these burdens, several European countries offer subsidy programs as incentives for those who meet or exceed these standards. Spain, for example, offers subsidies to farmers who meet higher animal welfare standards. While such standards can increase production costs, they can also increase market attractiveness, potentially affecting market dynamics and competition between EU products and imports (Rayment et al., 2010).

3.2.1.2.3 Policy impacts on externalities

In theory, establishing regulatory requirements serves as an effective tool to disseminate best practices widely. However, their effectiveness in addressing social and environmental externalities remains uncertain and varies in practice, often depending on the type of externalities targeted. Moreover, the results of these mandated measures are strongly influenced by the regional context, leading to different outcomes across European countries (Baaken, 2022; Ricci et al., 2022).

In the fisheries sector, the prescription of good practices through the Landing Obligation and technical measures has not yielded any environmental benefits (Wakefield, 2018). This consequence is attributed to issues such as low compliance, inadequate controls, and lack of economic incentives (Bohman, 2019; Borges, 2021; Communication from the Commission to the European Parliament and the Council towards more sustainable fishing in the EU, 2020). Economic benefits continue to drive discarding practices and illegal marketing, further escalating illegal trade. While the introduction of precise technical measures – regulating the conditions of fishing (i.e. where, when and how fishing can take place – is expected to reduce the ecological impact of fishing, evidence of their success remains scarce (Bellido et al., 2020; Dolman et al., 2021).

Another example is the Nitrates Directive, which aims to address water pollution by requiring measures to reduce nitrate pollution. Recent studies have questioned its effectiveness, suggesting that nitrate pollution persists (Gomes et al., 2023; Köninger et

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al., 2021; Ricci et al., 2022). Similar observations have been made about the EU's National Action Plans requested under the Sustainable Use of Pesticides Directive (2009/128/EC), which has been introduced to promote integrated pest management (IPM) and mitigate pesticide-related risks. While the directive aims to provide a framework for the sustainable use of pesticides, its implementation has largely been left to the discretion of individual Member States, resulting in different outcomes across countries (Helepciuc & Todor, 2021). In 2019, two Harmonized Risk Indicators (HRI) were introduced to assess pesticide toxicity. HRI 1, which assesses acute toxicity based on pesticide sales, reported a 17% reduction in associated risks. Conversely, HRI 2, which focuses on chronic toxicity through emergency registrations, showed a 56% increase. These mixed results have pushed experts and community groups to question the effectiveness of implemented measures aimed at reducing health and environmental risks from synthetic pesticides.

In contrast, some legal prescriptions have been shown to be effective in addressing specific issues. For example, measures prescribed for Spanish poultry farms to control ammonia emissions have also been cited as having an impact on methane emissions (Giner Santonja et al., 2017), although the link between ammonia and methane reductions would require further clarification. Increased public awareness and interest in issues such as animal health and welfare, as well as political importance, often leads to stricter regulations and improved management systems. In recent years, Spain has introduced more detailed regulations for the care of animals at various stages, from breeding, transport, experimentation to slaughter. As a result, consumer confidence in national and European animal welfare standards has increased significantly, encouraging the consumption of locally produced animal products by Spanish consumers over imported ones (Estévez-Moreno et al., 2021). The effectiveness of these policies could be attributed to the presence of economic incentives that help producers make the necessary changes. Similarly, the Swedish stringent national regulations have placed it among the countries with the highest animal welfare standards worldwide. Although these stringent regulations inevitably lead to higher implementation costs, their contribution to overall economic sustainability and performance for farmers remains mixed (Ahmed et al., 2020; Owusu-Sekyereet al., 2023).

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3.2.1.3 Quotas

3.2.1.3.1 Definition

Quotas are used as a policy instrument to regulate the quantity of a particular resource or good, that is produced, sold, or imported within a country, to achieve specific policy objectives.

Box 4: The Common Fisheries Policy
A good example lies in quota policy in the fisheries sector, where the EU's Common Fisheries Policy (CFP) regulates European fishing fleets and conserving fish stocks in the Northeast Atlantic (Borges, 2021) through Total Allowable Catches (TACs). TACs are set for each fish stock annually, or for longer periods, based on scientific advice. TACs are the central instrument of the CFP for achieving stock conservation objectives. TACs represent a use right to the resource, that is the right to fish in this case. By transferring fishermen, the ownership of fish, it encourages them to manage resources sustainably (Le Gallic, 2003; Libecap, 2009), thereby reducing negative externalities of fisheries.

3.2.1.3.2 Economic mechanisms of the instrument

Quotas can play an important role in internalizing externalities in the context of the food system by **regulating supply and maintaining higher domestic prices**. Moreover, a quota scheme can induce optimal resource allocation in markets with problematic externalities, albeit with some small welfare losses. The quota removal, as seen in the French dairy sector, can lead to a more competitive and **market-oriented** industry with the aim of increasing the **efficiency of production systems** through concentration, enlargement, and restructuring (Salou et al., 2017).

In the case of the TAC system, each Member State receives a **predetermined share or relative stability of the TAC based on historic catches**, but it is up to each Member State to decide how these quotas are to be allocated within the country (Nielsen et al., 2019). Individual transferable quotas (ITQs) have been adopted by many countries because they can improve the economic efficiency of fisheries. In Spain, the national fisheries administration distributes TACs to regional governments based on historical fishing rights. These regional governments then allocate the quotas to individual fishing vessels, then affecting their costs. This means that if one entity has an unused quota for a particular species, they can sell or lease it to another entity facing a shortage of that quota. This tradability creates economic incentives for efficient resource allocation. Indeed, if fishers exceed their allocated quota, they may need to purchase additional quota from others, incurring additional costs. Conversely, fishers who conserve and stay within their quotas can profit by selling excess quotas.

3.2.1.3.3 Policy impacts on externalities

Quotas might regulate stock externalities effectively, especially when resource stock monitoring is accurate, especially in the fishery sector (Koenig, 1984). In cases where production processes cause environmental damage, quotas can limit the negative externalities by capping production levels.

However, the effectiveness of the TAC system is still under debate, particularly because of its unintended effects. Concerns include slow adoption, inaccurate ex-ante information for setting TAC levels, and socioeconomic biases in TAC decisions (Borges, 2018; Carpenter et al., 2016; Le Gallic, 2003). Indeed, the TAC system can lead to distributional problems, potentially marginalizing small-scale fishers (Kane et al., 2022), while incurring significant costs in terms of implementation and operationalization (Le Gallic, 2003). Overall, the TAC quotas system seems to have had a limited success in effectively managing fish resources (Kane et al., 2022). Indeed, fishers may have an incentive to discard unwanted catches to maximize the value of their quota (Le Gallic, 2003). Despite the transition from a landing quota to a catch quota facilitated by the landing obligation, the illegal discarding of unwanted catches remains an attractive option for fishers seeking to maximize their economic profits under the TAC system. This is due to inadequate monitoring and insufficient economic incentives to discourage discarding, which in turn encourages practices detrimental to marine biodiversity and ecosystems.

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3.2.2 Market-based instruments

3.2.2.1 Taxes or charges

3.2.2.1.1 Definition

Environmental taxes or **charges** are market-based instruments that serve both as a monetary incentive for producers to adopt more environmentally friendly practices and to generate revenues that can be reinvested into environmental policies. In other words, by differentiating inputs or pollutants, this instrument is based on the "polluter pays" principle, which states that the costs of pollution should be borne by economic agents responsible for causing it.

Box 5: Pesticide tax in France and Romania

Some EU Member States have introduced environmental taxes or charges as part of a broader sustainability strategy. For example, **France**, Denmark, Norway, and **Sweden** have implemented environmental taxes on pesticides using different designs, tax rates, and objectives. While these environmental taxes aim generally to reduce the use of harmful pesticides, the Danish tax system is widely recognized as one of the most sophisticated in Europe. Denmark introduced a progressive tax system that uses a design according to the environmental impact of the specific input. The level of taxation of substances is determined by three factors: their level of toxicity, their potential for leaching into groundwater, and the volume used to measure environmental and health impacts. Then, the tax levy is determined per point rating, with products with higher points (i.e. more harmful) being taxed at a higher rate. Alternatively, as part of the EcoPhyto Plan, the French pesticide tax aims to decrease pesticide usage by 50% by 2025, while endorsing more sustainable agricultural practices. The French tax system considers both the volume and associated risks - both in terms of environmental and public health risks of the active substance in the pesticide - with quantity and hazard level both influencing the tax amount. Harmful pesticides are subject to higher taxation. Sweden's tax system, which is largely based on the amount of active ingredient, is more straightforward than Denmark's point-based system and somewhat comparable to France's risk-differentiated approach.

As for **Romania**, the government introduced a differentiated tax system for conventional and organic agricultural products, by lowering the VAT from 9% for conventional agri-food products to 5% for organically produced food. This policy serves the dual purpose of promoting organic farming and making such products more financially accessible.

3.2.2.1.2 Economic mechanisms of the instrument

The effectiveness of this fiscal measure is influenced by several elements: the **design and chosen tax rate**, the **structure of the incentives**, the **price elasticity of demand**, and the **precision with which it targets specific sectors or activities**.

Producers often express concern about input taxes because of the potential for **increased production costs** (Buchanan and Tullock, 1962). The introduction of a tax by its very nature affects *directly* **input prices**, the magnitude of which is determined by the design of the tax. The economic literature presents mixed evidence on such impact. In Denmark, the tax represents a significant portion of a pesticide's sales price (SEEID, 2017). France also uses a differentiated system, but at a lower rate, so the tax represents a smaller portion of the total cost of pesticides (Baudart, 2020). However, in these two countries, the result has been both a decrease in pesticide uses and, in some cases, **reduced profitability** for farmers. Considering farmers as rational profit maximizers, the effectiveness of a tax to reduce the use of harmful products depends on other elements. These factors encompass **price elasticities**, which vary depending on the product, time frame, and farming type (Falconer and Hodge, 2000; Böcker and Finger, 2017). The immediate effects of a tax on pesticides may be restricted owing to their low short-term price elasticity, which curbs farmers' responsiveness to price increases (Böcker and Finger 2017; Skevas et al. 2013).

One of the main objectives of this tax is to encourage the **substitution of harmful chemicals with non-chemical alternatives**, thereby steering agriculture toward more sustainable paths. Some countries have demonstrated positive results: Denmark, for example, saw a 16% decrease in pesticide use between 2012 and 2017 due to its pesticide tax (Nielsen et al. 2023). Similarly, in France, the implementation of such a tax led to a decrease in the use of high-risk chemical pesticides (Chakir and Thomas, 2022). The success rate of this transition, however, depends on issues such as farmer **adaptability and market conditions** (Gren, 1994). While these methods could be beneficial in the long run, they often require a significant initial investment (e.g. in education, staff training) and steeper learning curves (Popp et al., 2012). In addition, the transition can lead to temporary increases in production costs and potentially unpredictable yields, creating financial uncertainty for farmers. It is worth mentioning that, according to Lechenet et al. (2017), sustainable practices can help mitigate yield declines.

Farmers may pass on these additional tax-induced costs to consumers. The extent of this **pass-through on consumer prices** may vary depending on market dynamics, supply and demand, levels of competition, and policy responses. For example, in highly competitive markets, farmers may avoid passing on costs to consumers to maintain their market position. In contrast, in less competitive scenarios or for staples with stable demand, increased costs might be passed on. Distributors might also bear some of these costs to maintain sales (Femenia and Letort, 2016).

Finally, while there exist **transaction costs** associated with implementing environmental taxes, such as administrative and monitoring costs, they are typically small and manageable, as seen in the efficient Danish model (Aftab et al., 2017; Sud, 2020).

3.2.2.1.3 Policy impacts on externalities

While the definitive causal effect of the tax remains to be evaluated, preliminary observations suggest potential benefits. It may help reduce the negative impacts of pesticides on biodiversity, in line with broader national objectives such as climate change mitigation. In France, for example, efforts to reduce pesticide use have shown both ecological and environmental benefits, albeit indirect. In addition, reduced pesticide use is associated with reduced health risks for both agricultural workers and consumers. In

Spain, where agricultural practices rely heavily on pesticides, there have been concerns about long-term health effects. However, accurately quantifying these benefits is challenging due to factors such as delayed health effects and underreporting of chronic diseases.

But these potential benefits do not come without challenges. Reduced pesticide use could lead to increased vulnerability to pests, weeds, and diseases, which could undermine agricultural yields (Oerke and Dehne, 2004; OECD, 2007b; Savary et al., 2012,2019; Oliveira et al., 2014). This phenomenon can be observed in certain regions of Romania, where reduced pesticide use has sometimes led to crop losses.

While the intention behind the pesticide tax is to push farmers towards alternative pest control methods, the transition is not always seamless. These alternatives, while environmentally sound, can be unpredictable in maintaining yields. As seen in Sweden, farmers transitioning to alternative methods often face a steep learning curve and a potential initial period of yield loss, even if the long-term benefits are promising (Femina and Letort, 2016).

3.2.2.2 Subsidies

3.2.2.2.1 Definition

Subsidies refer to **direct or indirect financial grants or support** provided by a public entity to specific sectors, firms, or individuals, usually in the form of direct cash payments, tax breaks, or price supports. Their primary purpose is often to **make products or services more affordable**, to **encourage** the production or consumption of a particular good, or to **support sectors** deemed vital for sustainability reasons.

Box 6: The Common Agricultural Policy
The main source of subsidies and income support for agriculture in the EU is the Common Agricultural Policy. Under the CAP Programming Period 2014-2020, there are two central pillars of income support:
Pillar I: Direct payments including the Basic Payment Schemes:
The Basic Payment Scheme (BPS), which falls under Pillar I, provides direct income support to farmers based on the number of eligible hectares of agricultural land they own or manage. BPS is supplemented by other subsidy schemes tailored to specific actors in agriculture, such as initiatives for young and small farmers. Every farmer who benefits from CAP subsidies is bound by a basic set of norms called "conditionality". This conditionality, which includes mandatory greening and cross-compliance, requires farmers to meet certain standards in areas such as the environment, animal welfare, and food safety to be eligible for certain CAP direct payments.
Pillar II: Rural Development
Pillar II, on the other hand, allows Member States to provide additional targeted support to specific sectors or regions facing particular challenges. One of the key voluntary programs under Pillar II is the Agri-Environment-Climate Measures (AECMs). Its core objective is to incentivize farmers to adopt practices that support environmental protection, biodiversity, and climate adaptation. AECMs encompass a range of offerings to farmers, from programs that promote environmentally friendly farming practices to investments in renewable energy and energy efficiency. ***Focus on AECMs in Spain*** Spain has initiated several subsidies to promote the reduction of greenhouse gas emissions. These include subsidies for the renewal of the country's agricultural machinery fleet, support for projects to increase the environmental sustainability and competitiveness of agriculture, and support for the introduction of renewable energy systems and improved energy efficiency. These grants also cover the implementation

of remote electronic compliance monitoring systems, the digitalization of small-scale fleets, and the strengthening of the fisheries sector in various capacities. Such financial support is recognized as critical to overcoming technical and financial barriers and facilitating the adoption of better practices in the sector (Mills et al., 2020).

3.2.2.2.2 Economic mechanisms of the instrument

Governments use subsidies to provide financial support to selected industries or sectors to achieve various economic and political goals. In the agri-food sector, these subsidies critically **shape production, trade, and market dynamics**, and **guide the sector's overall economic outcomes**. While they can support employment and ensure the vitality of rural areas, their impact can vary across regions and Member States.

The primary goal of CAP **Pillar I subsidies** is to provide **income support**. From a value chain perspective, these subsidies can exert dual pressures on input and output markets. On the one hand, they can raise the price of inputs such as pesticides, fertilizers, land, and capital, creating windfall profits for input suppliers. On the other hand, they can suppress output prices, providing consumers with greater affordability of agricultural commodities (Goodwin & Ortalo-Magné, 1992; Kilian et al., 2012; Weersink et al., 1999). Because Pillar I subsidies are often tied to specific inputs or outputs, they may **catalyze both increased demand for inputs and increased supply of outputs**. This dynamic can undermine farm incomes-amplified input demand pushes up prices, increasing farmers' operating costs, while increased output supply can depress market prices and reduce revenues (Ciaian et al., 2015). For consumers, however, the CAP's direct subsidies often provide stability, dampening price volatility and ensuring consistent food affordability.

Conversely, **Pillar II CAP subsidies** are tailored to **compensate for potential income losses that farmers may experience when transitioning to less aggressive, more sustainable management**. Shifting to sustainable paradigms such as AECMs may require revisions in management strategies or the adoption of more expensive technologies, resulting in immediate cost increases. AECMs are also administratively burdensome, resulting in increased time, paperwork, and penalties for non-compliance

(Matzdorf & Lorenz, 2010). These can be daunting challenges, especially for smaller, financially strapped farms. The adoption of AECMs could also limit agricultural production in certain situations, potentially affecting the accessibility and cost-effectiveness of some products for consumers.

However, CAP Pillar II ultimately aims to motivate farmers to conserve the environment, biodiversity, and landscape. This not only enhances **product quality**, potentially allowing for **premium pricing**, but also increases **income streams** and the **development of niche markets**. In addition, by encouraging innovative and sustainable practices, such subsidies may increase production efficiency, thereby enhancing the market competitiveness of rural enterprises.

3.2.2.2.3 Policy impacts on externalities

Pillar I CAP subsidies use conditionality to push farmers toward environmentally friendly practices, which are intended to reduce environmental externalities (Hart et al., 2012). In the case of Pillar II CAP subsidies, their effectiveness depends on farmers' willingness to participate - a decision that is influenced by the transaction costs they would incur in these programs (Riccioli et al., 2023). Transactional challenges can result from additional labor, potential income losses, or administrative burdens associated with adapting to new farming practices. The outcomes of agri-environmental payments have been mixed, with some cases even showing negative environmental outcomes (Kleijn & Sutherland, 2003; Schmidtner et al., 2012; Zimmermann & Britz, 2016). This inconsistency in results is exacerbated by criticism of lax payment terms (Kleijn et al., 2004; Pe'er et al., 2014; Prager & Nagel, 2008) and the lack of a comprehensive evaluation structure (Pe'er et al., 2014). Nevertheless, where AECMs have resulted in beneficial environmental changes, there is a cascade of secondary benefits: increased agricultural productivity, production cost savings, and improved farm profitability over time. Furthermore, enhancing biodiversity and providing ecosystem services have the potential to generate co-benefits, including increased tourism, recreation, and improved quality of life in rural regions.

Despite the initial objectives, the prerequisites for subsidy eligibility can sometimes be seen as daunting and may not consistently ensure significant environmental improvements (Hart et al., 2012). The level of subsidy may then need to be rigorously evaluated to ensure that it is consistent with the desired policy objectives. For instance, in scenarios where subsidies are provided to compensate for mandatory animal culling due to disease risks, economic analyses suggest a potential drawback to complete compensation. Research literature indicates that farmers exert less preventive effort when they are offered full compensation of the animal's value rather than partial compensation. Partial reimbursement, serving as a method of risk-sharing, has been discovered to stimulate improved biosecurity practices among farmers (Barnes et al., 2015). This trend is not unique to the field of agriculture. An alarming relationship has been observed in the fisheries sector between overfishing and excessive subsidies, resulting in an overcapacity of the fishing fleet. Such trends emphasize the importance of carefully deciding on subsidy levels to prevent unintended adverse effects (Sumaila et al., 2010, 2019). Furthermore, the standardized nature of these prerequisites may not be sufficient to address unique regional environmental challenges. A significant barrier to measuring the effectiveness and environmental impact of subsidies is the lack of detailed data on their implementation and enforcement, and the challenge of linking specific environmental outcomes to these policies.

3.3 Policy instruments to internalize food system externalities affecting consumers

3.3.1 Administrative-based instruments

3.3.1.1 Mandatory regulations

3.3.1.1.1 Definition

Food safety is a priority for both consumers and policymakers. The quality of the production process has a direct impact on the standard of the final product sold to the consumer, ensuring high quality, safe and tasty food from farm to fork. To ensure high safety standards and protect public health, "command and control" instruments, often referred to as **mandatory regulations**, are central to many global food safety regulatory frameworks. These instruments specify directives, standards, and benchmarks that food producers must abide by. Their authoritative nature, combined with significant legal consequences, renders compliance imperative for food businesses.

The range of such mandatory regulations relevant to food production is broad and multi-faceted. From the outset, "input standards" concentrate on the purity and quality of the raw materials utilized in the food production process. Eliminating contaminants from these materials diminishes the risk of unsatisfactory final products. Following this, "Process Standards" deal with the intricacies of food production techniques. These regulations ensure that the processes utilized in production maintain the safety and authenticity of the food, guaranteeing the quality of the final product. Subsequently, the "Product Performance Standards" focus on the finished food items, establishing specific safety and quality criteria that must be met to ensure their safety for consumption.

Box 7: The Hygiene Package

The Hygiene Package is a set of regulations designed to ensure the safe and hygienic production, processing, and distribution of food within the European Union. Regulation (EC) No 852/2004 on the hygiene of foodstuffs is a fundamental element of the hygiene package, detailing the general hygiene requirements to be met by all food operators. It mandates that from farm to fork, everyone in the food chain must ensure that food is produced, handled, and transported under strict hygienic conditions. It firmly places the responsibility for assessing food safety risks on food businesses and requires them to implement and maintain hygiene procedures based on the Hazard Analysis and Critical Control Point principles. Regulation (EC) No 853/2004 further specifies the hygiene rules for food of animal origin. This regulation covers structural requirements for establishments, temperature controls, contamination prevention measures and health standards for animals intended for human consumption. Taken together, these regulations impose strict criteria for food handling, particularly for products of animal origin, with penalties for non-compliance ranging from product recalls to plant closures.

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3.3.1.1.2 Economic mechanisms of the instrument

Command-and-control food safety regulations are designed to internalize the economic factors associated with food safety violations by holding food producers financially responsible. By mandating compliance with **strict safety standards**, these regulations ensure that the costs associated with ensuring safety - such as prevention, control, and monitoring measures - are borne by producers. While this adherence to safety standards enhances credibility and customer loyalty (Caswell, 1998), it may also result in **higher production costs**. By setting strict standards for inputs, processing, and product performance, these regulatory frameworks require producers to invest in high-quality raw materials, state-of-the-art processing technologies, and rigorous testing procedures. By enforcing strict food safety regulations, governments aim to prevent negative externalities and place responsibility on food operators. They must ensure that the products they put on the market do not harm consumers. As a result, food industries strive to maintain acceptable levels of hazard to reduce the likelihood that their products will be associated with foodborne illness (Ollinger & Nicole, 2003).

Moreover, the nature of food safety differs from food quality attributes in that it remains largely hidden until after consumption. The costs of production may then be reflected in the price of the final product sold to and purchased by consumers. Thus, food safety often falls into the category of a post-experience good, where its safety and quality are only revealed after consumption (Focker & van der Fels-Klerx, 2020). This inherent characteristic leads to an information asymmetry between producers and consumers. Many consumers, lacking knowledge about potential food safety hazards, may not readily recognize or value enhanced safety attributes in products. Therefore, it is uncertain whether consumers would be willing to pay a premium for products with guaranteed safety measures (Focker & van der Fels-Klerx, 2020). Studies on consumers' WTP for food safety have been conducted in different countries. For example, in Spain, despite the implementation of the National Program for the Official Control of the Hygienic-Sanitary Conditions of Production of Traceability of Raw Milk from Cows, Sheep and Goats, which aims to protect public health and consumer interests, there is evidence that while there is considerable public awareness of the program, a significant portion of the Spanish population is not willing to pay a premium for this added assurance (Sans et al., 2005).

3.3.1.1.3 Policy impacts on externalities

Preventing foodborne illness through strong regulations helps reduce disease outbreaks and promotes better health and well-being for individuals. This increased assurance of food safety can increase consumer confidence, potentially leading to increased food consumption, which benefits the food industry. Indirectly, the reduced incidence of illness can lead to lower healthcare costs and increased productivity in the food industry, and then have positive externalities for society. However, absolute safety is not always achievable. A zero-risk criterion, while ideally desirable, is often infeasible, especially when dealing with microbial pathogens in unprocessed foods (Unnevehr & Jensen, 1996). Complete eradication of pathogens from food is a long-term goal, and even if achievable, the measures required could make food unaffordable for most people.

With respect to health and nutrition claims regulations, securing scientific validation is a laborious and costly process for the food industry. Gaining approval from EFSA for health claims in the EU can be particularly expensive. According to Brookes (2010), this undertaking could cost between €4.51 and €7.65 million, excluding the costs associated with clinical trials and confidential data submissions to EFSA for all foods. Addressing concerns raised by EFSA can be costly and may involve providing additional evidence or modifying claims to meet strict scientific criteria. Corrective actions may include reformulating products, adjusting labeling, or altering marketing strategies. Companies may experience a short-term increase in product prices due to reduced availability and market competition.

3.3.1.2 Information regulations

3.3.1.2.1 Definition

Mandatory food labelling refers to a government-imposed requirement for food producers and distributors to disclose specific information about the content, production, or handling of their products on the packaging, particularly on the **back of the package**. This intervention is a form of information regulation that aims to correct the information asymmetry between producers and consumers in the market.

Box 8: The INCO Regulation

In the European Union, food information is regulated by the Food Information to Consumers (FIC) Regulation, often referred to as INCO. As of December 13, 2014, most pre-packaged foods in the EU must carry a nutrition label to help consumers make informed dietary choices. These labels must include the energy value, total fat, saturated fat, carbohydrates, sugars, protein, and salt content, measured per 100 grams or 100 milliliters, with an optional indication per portion size. However, the EU has not standardized the presentation of nutrition information on the front of food packages. Liability enforcement remains critical to addressing market inefficiencies, particularly those arising from consumers' limited knowledge of product safety, producers' withholding of critical information, and manufacturers' inadequate safety protocols (Marette et al., 2003).

3.3.1.2.2 Economic mechanisms of the instrument

Mandatory food labeling plays a key role in correcting market failures and internalizing externalities, especially at the consumer level. The implementation of such requirements affects both **production costs** and **consumer prices**.

A prominent economic challenge in various markets is the information asymmetry between producers and consumers (Akerlof, 1970). Mandatory labeling bridges this gap by requiring producers to disclose key product details. As a result, consumers can make decisions that are more in line with their true preferences, thereby increasing market efficiency (Drichoutis et al., 2006).

Through labeling, producers can better adapt to consumer demands, thereby promoting competition based on product attributes rather than just price. Mandatory labeling can then lead to **market differentiation**, allowing producers to highlight unique

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product attributes and develop niche markets. Distinctive labels such as "gluten-free" or "fair trade" appeal to specific consumer segments and often command higher prices because of their specialization. In addition, labeling emphasizes product attributes, allowing consumers to distinguish superior products from their counterparts and giving producers the leverage to potentially raise prices if consumers value these attributes highly. These dynamic forces producer to raise standards or adopt sustainable practices, thereby promoting the internalization of positive externalities.

At the same time, the transition to mandatory labeling may impose costs on producers who must comply with the labelling standards, but they may also stimulate innovation and competition based on the attributes disclosed. **Investments** in new packaging, label updates, or increased testing can strain budgets. These increased costs can be passed on to consumers in the form of **higher prices**. With mandatory labeling, **regulatory compliance** is necessary. Manufacturers and suppliers must ensure that their labels meet established standards and regulations. Non-compliance can lead to penalties or product recalls, both of which can result in financial loss. These regulatory costs, as well as the potential risk of penalties, can affect the overall pricing structure in the marketplace.

3.3.1.2.3 Policy impacts on externalities

By providing consumers with clear, standardized, and accurate information about the nutritional content and other attributes of foods, mandatory labeling can influence dietary choices and promote healthier and safer eating habits. This increase in market transparency and reduction in information asymmetry (Akerlof, 1970) might increase consumer welfare by enabling individuals to make more informed purchasing decisions. Mandatory food labeling may then have an impact on public health. Informed consumers are more likely to make choices that are consistent with dietary guidelines, potentially leading to a reduction in diet-related chronic diseases such as obesity, diabetes, and cardiovascular disease (Hawley et al., 2013). In addition, back-of-package labels that identify allergens may prevent allergic reactions, thereby increasing consumer health safety. Furthermore, by imposing manufacturers to disclose certain ingredients or production methods, mandatory labeling can also indirectly encourage the food industry

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to reformulate products, potentially reducing harmful ingredients or contaminants, thereby improving the overall nutritional quality of the food supply (Mozaffarian, 2018). Such changes may not only benefit consumers, but can also lead to broader societal benefits, including reduced health care costs and increased productivity.

3.3.2 Market-based instruments

3.3.2.1 Taxes and charges

3.3.2.1.1 Definition

See Section 3.2.2.1.1 for a definition of taxes and charges. These fiscal measures can direct actions within sectors toward goals such as sustainability and improved public health. More specifically, consumer-level taxes are generally implemented at the national or regional level, as public health policies are initiated on a country-by-country basis rather than by larger entities such as the EU. Governments have the prerogative to use taxation as a tool to induce behavioral changes in individuals and industries (Temme et al., 2020).

Box 9: Tax on Sugar Sweetened Beverages

Sugar-sweetened beverages (SSBs) have come under increasing scrutiny due to their potential association with various health concerns, particularly excessive sugar consumption and obesity. In response to growing health concerns, several countries and regions have looked to fiscal policy, specifically the imposition of taxes on SSBs, as a means of curbing their consumption and promoting public health.

The French approach

France, known for its proactive approach to public health, has implemented policies to address SSB excessive consumption. In 2012, the French government introduced a tax on SSBs, which included both sugar-sweetened beverages and beverages containing artificial sweeteners. Given the changing nature of research and health recommendations, France re-evaluated and reformed the tax in 2018 to align it with current scientific and health priorities.

SSB tax in Catalonia and Spain's Nationwide Action

Recognizing the detrimental health effects of sugary drinks, the Catalan government took a decisive step in 2017 by introducing a specific tax on SSBs (Gobierno de Cataluña, 2017). Beyond Catalonia, the Spanish government also decided to raise the value-added tax (VAT) on sugary beverages based on research and advice from health experts (Ángel Martinez Jorge et al., 2022).

3.3.2.1.2 Economic mechanisms of these instruments

These taxes aim not only to discourage unhealthy consumption, but also to internalize the externalities of sugary drink consumption through various mechanisms.

One of the primary effects of taxes at the consumer level is to change **market prices**. This affects consumer choice, as higher prices may discourage individuals from purchasing unhealthy or environmentally unfriendly products. The effectiveness of SSB taxes also depends on how much of the additional **tax burden is passed on to consumers**. The food industry may choose to bear part of the tax increase, at the expense of some profits, in order to maintain consumer behavior. In France, the effectiveness of the SSB tax in terms of pass-through rates is mixed, likely due to the different econometric methods used in the studies (Capacci et al., 2019). However, French household data reflected price increases of between 4.9% and 9% for taxed beverages.

Second, such taxes can drive **product reformulation** within the food industry. This typically involves reducing sugar content or introducing alternative, healthier formulations to mitigate price increases and tax implications. France's progressive sugar tax in 2018 is an example of this, with a notable 6% reduction in sugar content in products within a year.

Finally, taxes at the consumer level increase **public awareness** of the health risks of excessive sugar consumption. Informed consumers can then strengthen support for such taxes, magnifying their positive impact on public health (Le Bodo et al., 2019; Acton et al., 2022; Brukalo et al., 2022). In addition to generating revenue, taxes can regulate risky behaviors and encourage healthier consumer choices. Funds generated by these taxes could also be redirected to support public health services and promote sustainable food production.

3.3.2.1.3 Policy impacts on externalities

The implementation of taxes, such as the tax on SSBs, has sparked global interest due to their potential impact on public health. Several studies have examined the effects of these taxes on consumption patterns, highlighting their potential long-term health consequences. While several studies have outlined the trajectory of SSB consumption in response to taxation, there is a notable gap when it comes to assessing direct health effects. The primary focus has been on assessing changes in consumption rates rather than the resulting health outcomes.

While the imposition of taxes on SSBs is increasingly recognized as a positive step toward improving public health, current research on their effectiveness has several limitations and challenges. These issues primarily revolve around the inconclusive nature of modeling studies, the limited scope of taxation, and the need for comprehensive long-term data. Much of the ambiguity in the research is due to uncertainties related to product substitution behavior. As highlighted by Ecorys (2014), modeling studies often struggle to accurately predict post-taxation consumer behavior. There is a legitimate concern that consumers may simply switch to untaxed sugary or unhealthy alternatives. This behavior can significantly undermine the health benefits that SSB taxes aim to achieve.

Another significant challenge arises from the somewhat narrow targeting of SSB taxes. They often focus on a limited selection of sugary products. While well-intentioned, this specificity may inadvertently limit the overall health impact of the tax. By focusing primarily on sugary beverages and excluding a wide range of other sugary foods and beverages, these taxes may miss the broader picture of consumers' dietary habits. The impact of such narrowly defined taxes risks being further diluted by the continued availability of a wide range of untaxed, unhealthy alternatives. The very essence of these taxes, which is to discourage unhealthy eating habits, could be rendered ineffective if consumers can easily shift their preferences to other sugary products that are not subject to the tax.

In addition, the current research paradigm underscores the urgent need to delve deeper into long-term health outcomes. Much of the existing literature lacks longitudinal studies that monitor and evaluate health trajectories over time. Such long-term data are essential to truly determine the tangible impact of reduced consumption of unhealthy products on chronic health conditions such as obesity and diabetes. To provide a holistic understanding of the health impact of SSB taxes, there's an urgent need for comprehensive surveys that look beyond immediate consumption patterns to elucidate broader health effects over time.

3.3.2.2 Voluntary labeling

3.3.2.2.1 Definition

Voluntary labels take a distinctively nuanced approach compared to "hard" policies. From an economic perspective, **certification and labelling instruments** serve to reduce information asymmetry, allowing consumers to make more informed purchasing decisions based on factors such as nutritional content, origin, production methods, and other attributes of interest. This information empowers consumers and potentially influences market dynamics, as producers may adjust their practices in response to consumer preferences revealed through purchasing behavior (Donato & D'Aniello, 2022).

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Box 10: Labelling schemes

Sustainability food labels

The growing emphasis on sustainable consumption in recent years has spurred several initiatives aimed at shifting consumer choices towards greener products. One notable strategy that has been widely adopted to promote this change is the use of sustainability labeling on food products. Ecolabeling is an increasingly important consideration for all stakeholders in the food system. First, they provide essential information to consumers and guide their consumption choices. Second, these labels have the potential to act as catalysts, with a ripple effect that encourages supply chain actors to adopt more sustainable practices. The presence of a sustainability label is the certification that signifies a company's commitment to green and ethical practices.

Sustainability food labels at the EU level

The EU has made significant efforts to promote sustainable food practices, and food labeling has played an important role in this journey. These labels serve as a guide for consumers, helping them make informed choices that benefit both the environment and their health. The EU organic logo has become a recognized benchmark of organic quality. Beyond its symbolic value, the logo assures consumers that the EU's strict organic standards, which emphasize ecological balance and biodiversity, have been met. To carry the label, a product must contain at least 95% organic ingredients, ensuring limited synthetic additives, no GMOs, and adherence to ethical animal treatment and natural farming techniques.

Sustainability food labels at the national level

Many countries have recognized the potential of such labels and have established national voluntary labelling schemes. **France**, for example, promotes its sustainable seafood (*Pêche Durable*) and high environmental value (*Haute Valeur Environnementale*, HVE) labels, while the **Swedish**-based food labeling system called KRAV Label stands for sustainability, animal welfare, health, and social responsibility.

The KRAV standards cover a wider range of producers and businesses and are in some cases stricter than the EU standards.

Front-of-Package Nutrition Labelling

The EU promotes transparency and informed consumer choices by instituting a legislative framework that supports the voluntary provision of front-of-pack nutrition information. As stated in EU Regulation (EU) 1169/2011, which focuses on offering food information to consumers, these front-of-pack labels must comply with the overarching EU law. However, this regulation provides the option for such labels, but member states are unable to enforce mandatory adoption. The framework promotes creative freedom for industries to communicate energy values and essential nutrient information to consumers effectively using alternative formats, including graphics or symbols (Gokani, 2022).

Two Front-of-Package Nutrition Labelling (FOPNL) schemes have emerged following various national evaluations: the Keyhole system from **Sweden** and the Nutri-Score system introduced by **France**. The Keyhole system represents a positive endorsement for certain food categories. Introduced in 1989 by the Swedish food agency, the label aims to emphasize essential food groups such as fruits, cereals, dairy, meat, and some prepared meals that conform to its nutritional standards. Since then, its recognition has extended beyond Sweden, being adopted in Denmark, Norway, Iceland, Lithuania, and North Macedonia (Pitt et al., 2023). The Keyhole system provides consumers with distinct markers for healthier choices within category-specific food segments. In contrast, the Nutri-Score provides a comprehensive approach by evaluating the nutritional profile of a broader variety of foods, considering both favorable and unfavorable characteristics. This enables a direct comparison of nutrient compositions across packaged foods and beverages. The Nutri-Score not only promotes healthier food choices but also highlights fewer desirable options. Launched in France in 2017, Nutri-Score has gained significant popularity and is currently being embraced by seven EU countries as of 2023. One of the standout features of Nutri-Score is its easily decipherable graded summary. Presented in a color/letter code format, it ranges from a dark green "A" for optimal nutritional value to a dark orange

"E" for products with the least nutritional value. Chantal et al. (2017) highlighted the primary goal of Nutri-Score: to streamline the process of comparing similar packaged foods. By differentiating products from the most to the least favorable, it empowers consumers with knowledge to make informed dietary choices. In addition, this system encourages food manufacturers to improve the overall nutritional value of their products in an indirect manner.

3.3.2.2.2 Economic mechanisms of the instrument

The introduction of consumer labels, including those related to sustainability and nutrition, has various implications for the economy and consumer behavior. While their aim is to inform and guide consumers, the labels can significantly impact the supply chain by affecting production costs and market dynamics.

For producers, meeting the high standards necessary to earn these labels may result in **increased production costs**. Obtaining certifications and shouldering labelling efforts come with added financial burdens.

This can be offset by **consumers willing to pay a premium** for sustainable or nutritious labeled products. Essentially, these labels offer added value and potential for premium pricing in the market. Cook et al. (2023) examine the factors that determine consumer demand for sustainability-labeled products, including expectations, public awareness, perception, preference, understanding, and trust. When consumers have a clear understanding of the meaning of the labels and trust their authenticity, they are more likely to purchase products that bear them.

Nutrition labeling has had a cascading effect on **product innovation and reformulation**. Data suggests that a FOPNL has the potential to catalyze the food industry, urging them to modify their products to make them healthier, especially when considering ingredients such as sugars and sodium (Vyth et al., 2010; van der Bend et al., 2020). For the Keyhole label, the study by Wanselius et al. (2022) shows that switching to Keyhole-approved alternatives for everyday foods has the potential to improve adolescents' nutrient intake (e.g., whole grains (+196%), saturated fat (-13%), and polyunsaturated fat (+17%), even with minor dietary substitutions (e.g., minimal improvements in consumption of free sugars (-3%) and salt (-2%)). The French Nutri-Score label has led to a promising decrease in unhealthy ingredients and an increase in beneficial ones, but it has also demonstrated the inadequacy of voluntary labels to truly improve food quality (UFC-Que Choisir, 2023). Braesco and Drewnowski (2023) also highlight the influence exerted on the labeling by concurrent public health interventions and marketing strategies. Beyond product reformulation, FOPNL labels can significantly impact **prices** and potentially influence **market competition**. However, the relationship between FOPNL labels and pricing requires further research.

3.3.2.2.3 Policy impacts on externalities

Sustainability labels have come to play an important role in influencing consumer purchasing habits. Choices based on these labels are aligned with broader initiatives for environmental consciousness and social considerations.

There is a fundamental overlap between the key sustainability goals of these labels, such as protecting the environment, ensuring social equity, and promoting animal welfare. For instance, labels including KRAV, FrånSverige and Svensk Sigill that put emphasis on animal welfare substantiate this argument. By promoting ethical treatment of animals, these labels enhance human health by potentially reducing the spread of zoonotic diseases and minimizing foodborne illnesses. The EU's organic label further consolidates this message by focusing on environmental and animal welfare, consequentially providing indirect health benefits through a cleaner ecosystem.

Although sustainability labels have gained significant attention, there is limited empirical evidence to assess their effectiveness in internalizing externalities. Some studies have examined the potential outcomes of labels like the French *Pêche Durable*, particularly in the sustainable fishing context. Beyond environmental concerns, consumers' choices also have an impact on the social aspects of production. Purchasing socially sustainable products ensures fair treatment of workers, ultimately resulting in positive economic outcomes for the agricultural industry. This could have a significant impact in terms of increasing profit margins for farmers (Tran & Goto, 2019).

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In the case of nutritional labels, Keyhole and Nutri-score have become essential in guiding consumers towards healthier products. Their straightforward design guarantees a basic understanding for most consumers. The Nutri-Score labeling system has demonstrated its effectiveness in facilitating consumers' improved assessment of the healthiness of products (De Temmerman et al., 2021), and consequently in reducing the purchase of unhealthy foods and beverages while promoting the purchase of healthier alternatives (Egnell et al., 2021; van den Akker et al., 2022, see for other European countries (Ares et al., 2018; Khandpur et al., 2018; Acton et al., 2018). In France, Nutri-Score has been shown to have a significant impact on consumer purchasing behavior, with up to 57% of respondents reporting having changed at least one purchasing habit because of Nutri-Score in 2020, compared to 43% in 2019 (Santé Publique France, 2021). Dubois et al. (2021) reported a 14% increase in purchases of foods with the highest nutritional value. However, evidence on the effectiveness of FOPNLs in 'nudging' consumers to purchase healthier foods remains mixed (Sacks et al., 2009; Graham et al., 2017; Peters & Verhagen, 2022). Limited effects may be due to consumers not fully understanding FOPNLs, limited use of these voluntary labels across different product types, and few product groups included in the studies, resulting in small effects on daily diets at the population level.

3.4 Conclusion

The creation of a policy mapping database of over 171 policies represents a significant step forward in understanding the policy framework for internalising externalities in the food system. In Task 2.1, through a literature review, we provide an impact assessment of these policies by type of instrument and thematic area. Globally, this review reveals a clear gap in the literature on the causal effects of these policies. In particular, the current state of the literature provides only a fragmented picture of the policy effects on costs, prices and externalities and makes it difficult to draw definitive conclusions on the effectiveness of the policy instruments considered since 2000. Moreover, the non-exhaustive nature of the policy framework at EU, national and regional levels also makes it difficult to draw a global picture of the gaps in policy interventions across the EU. While

Task 2.1 does not attempt to fill this gap, we delve into the economic mechanisms of these policies in order to better explain their potential impact.

4 New ideas

Task 2.1 of the FOODcOST project aligns with the EU objectives by identifying the main policy instruments that internalize unaccounted costs and/or benefits along the food chain, encompassing environmental and social dimensions, within the EU and in four different countries. Moreover, by evaluating policy instruments (e.g. food labeling, fiscal or regulatory measures, among others), our work provides insights on how the EU can efficiently improve its policies to ensure food sustainability. Based on the literature review of policy instruments and economic mechanisms, Section 4 suggests six policy-oriented ideas that could better internalize the externalities of the food system and two institutional priorities to help strengthen the EU policy framework for a sustainable food ecosystem. These new ideas have been identified based on the assessment of economic mechanisms and the most debated issues related to the impacts of food system activities. These include environmental concerns such as the impact of the food system on biodiversity and ecosystems, water stress, land use and climate change, as well as social externalities related to the health effects of diets, food safety and security, and animal welfare.

4.1 Policy-oriented new ideas to better internalize the externalities of the food system

4.1.1 New idea 1: Create a harmonized seafood sustainability label at the EU level to better inform consumption and production choices

Main externalities	Recommended policy instruments	WP5 Case study
Environment: Biodiversity and ecosystems	Market-based instrument: Label & certification	CS6
Social: Food safety		

A sustainability label on seafood serves as a tool to promote sustainability in the fisheries sector (Gutiérrez et al., 2012) and addresses significant environmental concerns caused by fishing methods (Washington, 2008).

At the supply chain level, the introduction of an ecolabel would promote best sustainable practices. This would increase transparency and traceability along the food chain in EU countries. Fisheries and suppliers that meet these standards would also benefit from marketability and visibility, further building consumer trust. On the consumer side, such a quality eco-label would contribute to build trust and bridge the gap between fishery industry and final consumers (Washington, 2008; Roheim et al., 2011; Christian et al., 2013) by improving information provision on seafood nutritional aspects, sustainability concerns, etc. To date, voluntary private national standards (e.g. Iceland's Responsible Fisheries logo) and international standards (e.g. MSC-certified seafood program since 2000) have been implemented. France has taken a distinct approach, introducing a public ecolabel called *Pêche Durable*.

However, the proliferation of labels has led to consumer confusion and undermined trust in sustainable fisheries. The design, clarity, and presentation of a label can influence consumer perception (Salladarré et al., 2010,2013; Brécardet al., 2012) and make a product more appealing. This, in turn, would influence consumers' willingness to pay a premium for sustainable products, allowing producers and the food industry to pass on costs to consumers. In addition, the distinction between wild and farmed fish raises unique environmental concerns that require tailored labeling strategies for each. While the primary environmental concerns for wild-caught fish are overfishing and habitat degradation, farmed fish raise questions about farming practices, chemical use, and water quality. As such, specific labels that address these specific challenges can provide consumers with clearer, more contextual information. In this case, it is arguable that endorsement labels may be more appropriate for wild fish, while a single ecolabel providing summary information on the environmental impact of the product may be more appropriate for farmed fish.

In addition to guiding consumer choices, an effective and standardized ecolabeling system has the potential to shape government policy. When governments recognize and adopt a widely accepted ecolabel, it can serve as a benchmark for developing legislative and fiscal measures. This may take the form of tax incentives or penalties tied to a product's environmental footprint, or even the imposition of strict regulations that effectively exclude products that do not meet established environmental criteria.

4.1.2 New idea 2: Implementing a harmonized FSA nutritional score for consumer guidance and taxation policy

Main externalities	Recommended policy instruments	WP5 Case study
Social: Health effects of diets	Market-based instrument: Front-of-package label and taxation scheme	CS4

To improve our dietary habits, it is necessary to identify the nutritional quality of products and therefore, to have a harmonized indicator at EU level. We suggest adopting the Food Standards Agency (FSA) system, which has applied to Nutri-score in France. This pioneering scoring system could have two main objectives: to offer consumers guidance when the score is made known to consumers (through the Nutri-Score) and to function as a metric for a potential fiscal incentive.

First, the introduction of a mandatory front-of-package nutrition labeling system on all products in the EU could serve as an economic tool to improve transparency and consumer choice (Gokani and Garde, 2023). As the EU grapples with growing public health concerns, such as rising obesity rates and diet-related diseases, making the Nutri-Score mandatory can be seen as a proactive strategy to encourage both producers to reformulate their products and consumers to adopt healthier lifestyles. First, making this system mandatory throughout the EU not only standardizes how food ingredient information is presented but also creates a level playing field for businesses, eliminating disparities between voluntary and mandatory adoption. This could also encourage the food industry to reformulate their products to achieve a better Nutri-score and thus gain market share in the 'healthy products market' (Vyth et al., 2010; van der Bend et al., 2020). Second, the Nutri-Score system provides at-a-glance information on the nutritional quality of foods and could enable consumers to quickly distinguish between healthy and unhealthy products at low cost (Becker et al., 2016; Graham et al., 2015; Egnell, 2020; Santé Publique France, 2021).

The implementation of this labeling system has potential economic implications. While it empowers consumers, it may impose financial burdens on producers, particularly in terms of relabeling and reformulating product content. The costs may fall disproportionately on SMEs, while larger companies with economies of scale and greater financial resources may be able to adapt more smoothly.

Second, the introduction of the FSA nutritional score could serve as a baseline metric for policy makers to identify and tax products that fall below certain nutritional benchmarks. This would help create incentives for the food market to improve the nutritional quality of products.

Indeed, in the face of growing global health concerns, public authorities such as France, the United Kingdom, the Spanish government, and Catalonia, are increasingly recognizing the potential role of fiscal measures in promoting healthier lifestyles, by taxing soda products. As demonstrated in our literature review, there is no controversy surrounding the soda tax due to the established link between the obesity prevalence and soda consumption. Therefore, it could be recommended to implement this tax in all EU member states. However, taxing only a narrow market could not lead to high reduction in health externalities. Imposing a tax scheme on all products having a poor nutritional quality seems to be a strategic economic tool to deeply change consumption patterns. First, such policy could discourage consumers from purchasing unhealthy products and reduce substitution effects for these types of products. By making all these unhealthy products more expensive, it could nudge consumers toward healthier alternatives and encourage dietary change (Le Bodo et al., 2019; Acton et al., 2022; Brukalo et al., 2022). Second, it could encourage the food industry to reformulate their products when the tax is based on the targeted nutrient (Allcott et al., 2019; Allais et al., 2023). A simultaneous tax on all unhealthy products could also offset the rising health care costs associated with treating chronic NDCs.

The tax could take different forms: an excise tax on the FSA score and/or a change in VAT (a VAT reduction for healthier products with higher FSA scores such as vegetables and fruit, a VAT increase for unhealthier products with low FSA scores). The design of the tax is important and affect the efficiency. This should be carefully considered.

4.1.3 New idea 3: Create a mandatory labelling scheme on animal welfare

Main externalities	Recommended policy instruments	WP5 Case study
Social: Animal welfare	Market-based instrument: Label	

The EU has long been at the forefront of establishing progressive policies, especially those that balance economic viability with social and ethical considerations. A cornerstone of the EU's Farm to Fork Strategy for a Healthier and More Sustainable Europe is the inclusion of a discussion on animal health and welfare. Advocating for animal welfare is often seen as a reflection of our moral obligations, embodying compassion, and a commitment to prevent unnecessary suffering. Implementing a policy instrument on animal welfare could in that sense address growing concerns about inhumane treatment in the livestock sector (Bonnet et al., 2020).

In general, many costs associated with livestock production, particularly those related to environmental degradation, societal health impacts, and poor animal welfare practices, are externalized. That is, they are not borne by farmers or food producers, but are instead passed on to society or the environment. Internalizing these externalities in the food system would mean more accurately reflecting the true costs of food production. Further policy efforts are needed, such as the introduction of a harmonized front-of-package label for ethical supply chains. Improved animal welfare could also lead to better product quality, reduce the risk of zoonotic diseases, and have the potential to strengthen the economy by catering to a growing population of welfare-conscious consumers.

In the past ten years, labeling initiatives informing consumers on animal welfare in food production have emerged among the EU Member States. There exist two mandatory animal welfare labels: the egg coding system and the German Animal Husbandry Labeling. The egg coding system is based on the EU legislation for laying hens and indicates different production methods and living conditions from 0 to 3 (cages, free range, barn, etc.). Animal Husbandry Labeling (*Tierhaltungskennzeichnung*) is the mandatory labeling of the living conditions of livestock originating in Germany, in force since August 2023. The German federal Act on Animal Husbandry Labeling describes the living conditions of the animals during their "production period". For pork, this refers to the fattening period but ignores the living conditions during the rearing of piglets and sows. The label distinguishes between the following five living conditions (from best to worst): EU organic, outdoor/outdoor, indoor with fresh air, indoor+outdoor, indoor.

Except for these two mandatory labels, most animal welfare labels are voluntary. Examples in Europe include the UK's RSPCA Assured and Denmark's state-controlled Animal Welfare Label, which almost all retail chains are involved in developing and actively promoting to their suppliers. The Danish animal welfare label is a state-controlled labelling scheme that is *de facto* mandatory as it demanded by practically all retail chains. The current landscape on animal welfare policy framework paints a picture of ambiguity, with voluntary labels which might be well-intentioned but can lack the rigorous standards and third-party compliance checks crucial for authenticity. In France, an associative initiative has led to the creation of a unique animal welfare label, the *Etiquette Bien-être animal,* with a rating system like the Nutri-score. This voluntary animal welfare label aims to provide consumers with clear, reliable, and robust information on the living conditions of the animals from which the marketed products are derived, from birth to slaughter, including breeding and transport. The label presents two types of information: the level of animal welfare, ranging from A to E, based on several hundred criteria, and the production system. The rating is also based on an annual audit by an independent auditor. In addition, the EU organic farming rules encourage a high standard of animal welfare.

The ongoing initiatives by associations and Member states highlight the urgent need for a harmonized, comprehensive, and mandatory animal welfare labeling system. Such a system should not only inform but also educate consumers, allowing them to make ethical choices confidently. It should also reward producers who genuinely prioritize animal welfare, thus promoting a more humane and sustainable supply chain.

4.1.4 New idea 4: Balance between animal and plant-based protein diets

Main externalities	**Recommended policy instruments**	**WP5 Case study**
Environment: Climate change, Biodiversity and ecosystems, Land use	Mix-policy including:	CS4, CS7, CS11
	Market-based instrument: fiscal measures	
Social: Health effects of diets, Food safety, food security	Administrative-based instrument: public procurement	
	Educational campaigns	

Balanced diets could contribute to climate change adaptation and mitigation, while providing co-benefits for human health (Carlisle, 2014; Magrini et al., 2018; IPCC, 2019; Willett et al. 2019; IPCC, 2019). Promoting diets based on pulses - such as lentils, chickpeas, beans, and peas - as opposed to meat-heavy diets can be an effective policy tool to address major challenges in the food sector, such as pesticide use, climate change, and natural resource scarcity (e.g., land use) (Kremen et al., 2012; Ndzana & Magro, 2014). Reducing meat consumption could also significantly reduce greenhouse gas emissions (Kustar & Patino-Echeverri, 2021), biodiversity loss, deforestation, and water use associated with livestock production (Irz et al., 2016; Willet et al., 2007, 2019). Plant-based products are also known to improve human health by preventing overweight and obesity (Mollard et al., 2011; Didinger et al., 2022), type 2 diabetes (Dahl et al., 2012; Champ et al., 2015; Jardine et al., 2021; Wang et al., 2022), and cardiovascular diseases

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(Wang et al., 2015; Kahleova et al., 2018; Dahl et al., 2012; Bazzano et al., 2011), as well as a lower Body Mass Index (Marrone et al., 2021), and different types of cancer (Oussalah et al., 2020; Ibragimova et al., 2021; DeClercq et al., 2022; Gupta et al., 2022). From a societal perspective, pulse-based diets could help address issues of food security and malnutrition, as these crops are often more affordable and accessible than meat in various parts of the world.

Unfortunately, current EU legislation does not adequately support the shift of consumers towards a more plant-based diet and the development and uptake of plant-based alternatives that could facilitate such a transition, as outlined in the Farm-to-Fork Strategy. To this end, a mixed policy framework is needed to better support plant-based products and address the environmental footprint of the livestock sector, including the introduction of a more balanced tax system for animal and plant-based products that internalizes their respective externalities, together with incentives for public procurement to promote plant-based diets. However, it also depends on the animal and plant species.

One policy response is to regulate red and processed meat consumption through fiscal measures. A tax could help internalize unaccounted societal costs and health risks linked to meat consumption by adjusting market prices. According to Springman et al. (2018), an optimal tax could increase prices by up to 4% for red meat products and 25% for processed meat products. Assuming full pass-through to consumers, the tax could reduce meat consumption by 16% on average worldwide. Regarding the targeted externality itself, a meat tax targeting only public health concerns would be less effective in reducing red meat consumption compared to a tax designed to internalize the environmental costs associated with meat consumption (Springman et al., 2018). One way to deal with these conflicting effects could be to consider both externalities when promoting the implementation of a meat tax at the EU level. Moreover, it is imperative to transition towards sustainable food sources, instead of supporting unsustainable ones, notwithstanding the significant amount of food subsidies provided. In addition, combining a meat consumption tax with EU-wide 0% VAT rates for plant-based products could enable consumers to switch to alternative meat products.

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On the other hand, public procurement is an innovative strategy to promote sustainable food choices (Carmichael, 2019; Nunez Ferrer, 2020; WHO, 2022; Sapir et al., 2022). The inclusion of plant-based foods in the EU's mandatory criteria for sustainable public procurement can play a key role in achieving broader societal goals (IPES-Food, 2018), including reducing greenhouse gas emissions from the food sector, promoting biodiversity, and addressing diet-related health issues. However, the potential of public procurement as a climate policy tool remains largely untapped in the EU (Sapir et al., 2022). These policy instruments need to be accompanied by education in order to deeply change habits and social norms and avoid compensatory effects in other consumption occasions, and then achieve sufficient influence on dietary choices or intake.

4.1.5 New idea 5: Strengthen the implementation of bans of the most harmful pesticides and introduce fiscal measures on others

Main externalities	Recommended policy instruments	WP5 Case study
Environment: Climate change, Biodiversity and ecosystems, Land use	Mix-policy including:	
	Market-based instrument: fiscal measures (tax and subsidies)	
Social: Food safety	Administrative-based instrument: regulation	

Achieving a 50% reduction in the use of pesticides in the agricultural sector is one of the main objectives of the EU's Green Deal. Reducing pesticide use can potentially lead to more sustainable and safer food systems while minimizing environmental impacts. Identifying the technical levers is not enough to trigger the agro-ecological transition to achieve this goal. It also requires the implementation of incentive instruments that internalize the costs of pesticide use in terms of environmental, social, and economic externalities.

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Regulation remains a key policy instrument in the European Union. They make it possible to remove a product from the market and send a strong signal to all economic actors about public health and environmental costs. Regulatory instruments can be effective in reducing environmental degradation and biodiversity loss and could be a good policy tool to eliminate the most harmful pesticides from the food system altogether. However, bans can jeopardize agricultural productivity and threaten farmers' livelihoods without viable alternatives. Indeed, banning a pesticide without compensating for the loss of profitability may not help farmers to redesign their production systems, especially in the context of climate change and pest outbreaks (see the case of the neonicotinoid ban in France). In other words, regulations should be coupled with an EU-wide tax system on other (less harmful) pesticides to facilitate the transition to sustainable food production systems.

An EU-wide tax system may also be economically burdensome for farmers and less effective. Pesticide taxes are often contested by various interest groups, leading to suboptimal design and implementation. For example, while the French pesticide tax was found to be ineffective in shifting pesticide use because of the low tax rate on harmful substances, the tax design proposed in Denmark appears to be more effective because it takes toxicity into account and reduce the risk of pesticide substitutions. An alternative and more acceptable policy could be a combination of a tax and a redistribution mechanism: while heavily taxing the use of pesticides, governments would redistribute the revenue directly to farmers. This revenue could be used to support sustainable farming practices for new adopters and help sustain organic farming through additional subsidies, especially given its reduced emphasis in the new CAP agenda (2017-2023). In addition, the funds could be used to educate farmers about integrated pest management, agroecology, or organic farming. Since both a ban and a tax could lead to substitution with other environmentally harmful products (e.g. copper), further interdisciplinary research to find alternatives to pesticides is crucial.

4.1.6 New idea 6: Balance productivity goals with sustainable water management

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Main externalities	Recommended policy instruments	WP5 Case study
Environment: Water stress, Biodiversity and ecosystems	Market-based instrument: Tax and/or subsidies	CS3
Social: Food security		

Balancing the productivity of the agriculture and food sector with sustainable water management is of paramount importance in today's rapidly changing global environment, diminishing freshwater supplies and a growing global population. The agricultural and food sectors face increasing risks, while remaining heavily dependent on water and being a major source of water pollution. There is a growing urgency to ensure that water is used wisely along the food systems (Vanham and Leip, 2020) by reforming water policies related to the food systems (Gruère et al., 2018: Uhlenbrook et al., 2022). Water resource management and pollution control are in general local issues that require policy interventions to be carefully tailored to accommodate the unique environmental, socio-economic contexts of specific geographical regions and agricultural production systems.

The EU and Member States have a role to play by strengthening the resilience of the food sector in areas facing increasing water risks and by creating incentives to improve water use. To date, however, there is no consensus on the most efficient and socially acceptable policies along the food chain, from producers to consumers. A multi-dimensional approach that combines economic incentives with the promotion of advanced water-saving technologies might be essential. By balancing financial incentives with sustainable practices, the agricultural sector can drive this change and become a leader in water conservation and management.

First, fiscal measures on excessive water use or pollution can provide incentives for the agricultural sector and food industry to adopt better water management practices that internalize environmental costs (OECD, 2018). A potential tax policy, implemented in some French watersheds, could be to introduce a pricing system with a fixed component based on surface area or subscribed volume and a variable component based on volume consumed (Guettier, et al., 2019).

Second, encouraging farmers to implement water reuse systems can significantly reduce the overall demand for freshwater. By providing financial incentives (tax breaks, subsidies, or low-interest loans), farmers can be motivated to invest in infrastructure that treats and reuses agricultural runoff or graywater from urban areas. For example, greywater from domestic activities such as washing dishes or laundry, after appropriate treatment, can serve as a valuable irrigation resource, reducing dependence on freshwater sources. Another strategy to promote sustainable water use is to incentivize water harvesting methods. These can include rainwater harvesting systems that capture and store rainwater for agricultural use, or even building a small water tank next to the field to collect water from heavy rains, especially in areas prone to prolonged drought. However, while these systems could further encourage farmers to adopt water-saving (e.g. irrigation systems) and risk-resilient technologies, this would significantly increase production costs and thus place an additional burden on consumers, especially low-income households.

4.2 Institutional priorities

4.2.3 New idea 7: Creation of a harmonized EU framework

Food systems are complex, involving food, health, environmental, food industry, and consumer. The EC underlines the urgency of putting food sustainability on the political agenda. As discussed in the synthesis, there are significant policy, regulatory, financial, technical, and behavioral challenges to be addressed given the fragmentation and slow adaptability of current food systems. Persistent barriers to improving sustainable food systems stem from the lack of an EU framework, which is not sufficiently compensated by the involvement of national governments (EC Food 2030 IEG, 2018). Our mapping shows that public policies at the EU level are less stringent than those at the national level, with many directives allowing individual Member states discretion in policy adoption.

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4.2.4 New idea 8: Strengthen research on the evaluation of public policies in the food system, before and after their implementation, and relying on the outcomes to build a more efficient EU policy framework

Comprehensive research is essential to quantify the causal impact of policy instruments on environmental, social, and economic externalities. In all WP2.1 individual reports, the panel experts have identified a huge gap in interdisciplinary research and lack of policy evaluation along the food value. Social sciences can help understand the key economic mechanisms that influence food-related decisions and behavioral changes. Moreover, economic evaluation assessment tools, such as cost-benefit and socio-economic studies, are urgently needed for informed risk management about potential benefits and costs before and after the policy implementation (Deconinck & Toyama, 2022).

The focus should be on creating an interface between science, policy, and society on food systems; improving the impact of food systems research, assessment, modeling, and monitoring; and investing in evidence-based communication and knowledge exchange.

To rigorously quantify the causal impact of policy instruments on the multiple externalities of the food system, we recognize the need for a robust framework of indicators and comprehensive datasets. In line with the findings of the expert panel, we acknowledge the interdisciplinary research gap and the need for accurate policy evaluation across the food value chain. We therefore propose the following concrete actions:

- Establish *ex-ante* and *ex-post* causal impact evaluations of public policies.
- Ensure all researchers have unencumbered access to granular/local data necessary for policy evaluation, removing administrative and cost burdens to foster a collaborative research environment.
- Legally require that field experts regularly update these evaluations, ensuring continuous improvement and relevance.
- Strengthen interdisciplinary collaborations, particularly between social sciences and other scientific fields, to enhance the understanding of economic mechanisms and behavioral responses.

These new ideas were presented and discussed at the MML meeting held on October 18th, 2023, as well as the subsequent COP meetings. Some of these new ideas will be tested in forthcoming case studies within WP5 or carried over into WP6. Task 2.3 of FOODCoST is responsible for providing final recommendations based on Deliverable 2.1 and the findings from the case studies.

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6 Appendix

6.1 Main definitions

Public policy	A public policy includes actions of government and/or public agencies to convert competing private objectives into public commitments. Public policies are purposeful decisions made by authoritative actors in a political system who have the formal responsibility for making binding choices among societal goals. Public policy is a form of government control usually expressed in a law, a regulation, or an order. Since it reflects an intent of government, it is backed by an authorized reward, incentive, or penalty (Cochran and Malone, 2005, p. 13).
Direct effects	Direct effects deal with the intended impacts of a policy. These direct effects are explicitly specified and defined within the policy's legal framework. Indirect effects are defined as all other impacts that are not initially targeted by the policy but are indirect consequences.
Indirect effects	Indirect effects are defined as all other impacts that are not initially targeted by the policy but are indirect consequences.
Policy mix	A policy mix represents a combination that a government entity (EU, national, regional, or local) can form with different policies (market-based, administrative, etc.) according to a common objective and the initial situation in which the government entity finds itself. The general principle is that the joint use of these policies can serve different or cross-functional economic strategies and then imply implementing different policy instruments.
Primary target	Main economic group towards which the policy action is directed or applied by the instrument
Ultimate beneficiary	Economic group that is linked to the overall policy goal (e.g., a sugar tax affects the industrial sector but is intended to promote

	healthy eating habits among consumers who thus are the ultimate beneficiaries)
Market price	Monetary value of a good, service or resource established during a transaction
Total cost of production	The total cost of production (or explicit costs) is the total expenditure incurred during the production process. Total cost is the sum of variable and fixed costs.
Explicit (accounting) costs	Explicit (accounting) costs include: ▪ Variable costs (or total variable cost) are the costs paid to the variable input. They depend on the quantity produced. ▪ Fixed costs are perfectly independent of the quantity produced. They are the costs of the fixed assets those that do not vary with production (e.g. maintenance of premises, property taxes, etc.). Inputs include labour, capital, logistics, processing, materials, power and land and buildings, etc.

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6.2 List of public policies covered in Deliverable 2.1

6.2.1 European Union

Regulation (EU) No 1305/2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD)

Regulation EU) No 1307/2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy

Regulation EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007

Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC

Regulation (EC) No 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed

Commission Regulation (EU) No 619/2011 of 24 June 2011 laying down the methods of sampling and analysis for the official control of feed as regards presence of genetically modified material for which an authorisation procedure is pending or the authorisation of which has expired.

Regulations (EC) 1830/2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC

Regulation (EC) No 1946/2003 of the European Parliament and of the Council of 15 July 2003 on transboundary movements of genetically modified organisms

Regulation EC 396/2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin

Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC

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Commission Implementing Regulation (EU) No 540/2011 of 25 May 2011 implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards the list of approved active substances

Regulation (EU) 2019/1381 on the transparency and sustainability of the EU risk assessment in the food chain

Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides

Directive 2000/60/EC

Directive 2008/105/EC on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council

Directive 2013/39/EU amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy

Directive 2006/118/EC

Regulation (EU) 2019/1009 — laying down rules on the making available on the market of EU fertilising products

Directive 91/676/EEC Concerning the protection of waters against pollution caused by nitrates from agricultural sources

Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive ;MSFD)

Regulation (EC) No 1005/2008 Establishing a community system to prevent, deter and eliminate illegal, unreported and unregulated fishing,

Regulation (EC) No 1224/2009 Establishing a Union control system for ensuring compliance with the rules of the common fisheries policy

Regulation (EU) 2017/2403 of the European Parliament and of the Council of 12 December 2017 on the sustainable management of external fishing fleets, and repealing Council Regulation (EC) 1006/2008

Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy

Regulation (EU) No 1379/2013 of the European Parliament and of the Council of 11 December 2013 on the common organisation of the markets in fishery and aquaculture products, amending Council Regulations (EC) 1184/2006 and (EC) 1224/2009 and repealing Council Regulation (EC) 104/2000

Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund and repealing Council Regulations (EC) 2328/2003, (EC) 861/2006, (EC) 1198/2006 and (EC) 791/2007 and Regulation (EU) No 1255/2011 of the European Parliament and of the Council

Regulation (EU) 2021/1139 of the European Parliament and of the Council of 7 July 2021 establishing the European Maritime, Fisheries and Aquaculture Fund and amending Regulation (EU) 2017/1004

Regulation (EU) 2019/1241 of the European Parliament and of the Council of 20 June 2019 on the conservation of fisheries resources and the protection of marine ecosystems through technical measures, amending Council Regulations (EC) 1967/2006, (EC) 1224/2009 and Regulations (EU) No 1380/2013, (EU) 2016/1139, (EU) 2018/973, (EU) 2019/472 and (EU) 2019/1022 of the European Parliament and of the Council, and repealing Council Regulations (EC) 894/97, (EC) 850/98, (EC) 2549/2000, (EC) 254/2002, (EC) 812/2004 and (EC) 2187/2005

Regulation (EU) 2019/473 of the European Parliament and of the Council of 19 March 2019 on the European Fisheries Control Agency. It repealed Council Regulation (EC) 768/2005 of 26 April 2005 establishing a Community Fisheries Control Agency and amending Regulation (EEC) No 2847/93 establishing a control system applicable to the common fisheries policy.

Directive 2003/99/EC of the European Parliament and of the Council of 17 November 2003 on the monitoring of zoonoses and zoonotic agents, amending Council Decision 90/424/EEC and repealing Council Directive 92/117/EEC

Regulation (EC) No 2160/2003 on the control of salmonella and other specified food-borne zoonotic agents

Council Regulation 1/2005 of 22 December 2004 on the Protection of Animals during Transport and Related

Regulation (EC) No 1069/2009 laying down health rules as regards animal by-products and derived products not intended for human consumption

Regulation EC 1375/2015 laying down specific rules on official controls for Trichinella in meat

Regulation (EU) 2016/429 of the European Parliament and of the Council of 9 March 2016 on transmissible animal diseases (Animal Health Law)

Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products, amending Regulations (EC) No 999/2001, (EC) No 396/2005, (EC) No 1069/2009, (EC) No 1107/2009, (EU) No 1151/2012, (EU) No 652/2014, (EU) 2016/429 and (EU) 2016/2031 of the European Parliament and of the Council, Council Regulations (EC) No 1/2005 and (EC) No 1099/2009 and Council Directives 98/58/EC, 1999/74/EC, 2007/43/EC, 2008/119/EC and 2008/120/EC, and repealing Regulations (EC) No 854/2004 and (EC) No 882/2004 of the European Parliament and of the Council, Council Directives 89/608/EEC, 89/662/EEC, 90/425/EEC, 91/496/EEC, 96/23/EC, 96/93/EC and 97/78/EC and Council Decision 92/438/EEC (Official Controls Regulation)

Regulation 2019/6 of 11 December 2018 on veterinary medicinal products and repealing Directive 2001/82/EC, 2018

Regulation 2019/4 of 11 December 2018 on the Manufacture, Placing on the Market and Use of Medicated Feed

Regulation (EC) No 1331/2008 of the European Parliament and of the Council of 16 December 2008 establishing a common authorisation procedure for food additives, food enzymes and food flavourings

Regulation 1333/2008 on food additives

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Regulation 1334/2008 on flavourings and certain food ingredients with flavouring properties for use in and on foods

Regulation 1332/2008 on food enzymes

Regulation 609/2013 on food intended for infants and young children, food for special medical purposes, and total diet replacement for weight control

Regulation 1924/2006 on nutrition and health claims made on foods

Regulation 1169/2011 on the provision of food information to consumers

Regulation 2016/127 as regards the specific compositional and information requirements for infant formula and follow-on formula and as regards requirements on information relating to infant and young child feeding

Regulation (EC) No 834/2007 on organic production and labelling of organic products

Regulation (EEC) No 315/93 — EU procedures for contaminants in food

Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs

Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC

Commission Regulation (EU) 2019/649 of 24 April 2019 amending Annex III to Regulation (EC) No 1925/2006 of the European Parliament and of the Council as regards trans-fat, other than trans-fat naturally occurring in fat of animal origin -Trans fat

Regulation (EC) No. 853/2004 of the European Parliament and of the Council laying down specific hygiene rules for the hygiene of foodstuffs.

Regulation (EU) No 605/2010 laying down animal and public health and veterinary certification conditions for the introduction into the European Union of raw milk, dairy products, colostrum and colostrum-based products intended for human consumption

Regulation (EU) 2015/2283 of the European Parliament and of the Council of 25 November 2015 on novel foods, amending Regulation (EU) No 1169/2011 of the

European Parliament and of the Council and repealing Regulation (EC) No 258/97 of the European Parliament and of the Council and Commission Regulation (EC) No 1852/2001

Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs

Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs

Commission Regulation (EC) No 1020/2008 of 17 October 2008 amending Annexes II and III to Regulation (EC) No 853/2004 of the European Parliament and of the Council laying down specific hygiene rules for food of animal origin and Regulation (EC) No 2076/2005 as regards identification marking, raw milk and dairy products, eggs and egg products and certain fishery products

Commision Regulation (EC) No 2023/2006 on good manufacturing practice for materials and articles intended to come into contact with food

Commission Implementing Regulation (EU) No 203/2012 of 8 March 2012 amending Regulation (EC) No 889/2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007, as regards detailed rules on organic wine

Regulation (EU) No 1169/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004

Funded by the European Union

Biofuel penetration targets/GHG intensity reduction targets

Carbon Border Adjustment Mechanism

EU Regulation on the organization of markets. Entry price system for fruits and vegetables.

Due diligence in international supply chains

Maximum residue level/ SPS standards

Deforestation-free supply chains

6.2.2 France

Article 46 du projet de loi de finances (PLF) de 2012 and Article 26 LOI n° 2011-1977 du 28 décembre 2011 de finances pour 2012 - Contribution sur les boissons sucrées ou édulcorées

Arrêté du 31 octobre 2017 fixant la forme de présentation complémentaire à la déclaration nutritionnelle (NutriScore)

Article 19 LOI n° 2017-1836 du 30 décembre 2017 de financement de la sécurité sociale pour 2018 - Contributions sur les boissons non alcooliques contenant des sucres ajoutés

Article 1613 ter du code général des impôts (CGI) - Contribution sur les boissons contenant des édulcorants

Décret n° 2012-104 du 27 janvier 2012 relatif à l'écolabel des produits de la pêche maritime

Arrêté du 28 novembre 2003 relatif aux conditions d'utilisation des insecticides et acaricides à usage agricole en vue de protéger les abeilles et autres insectes pollinisateurs

Décret no 2007-358 du 19 mars 2007 relatif à la dissémination volontaire à toute autre fin que la mise sur le marché de produits composés en tout ou partie d’organismes génétiquement modifiés

Arrêté du 19 mars 2007 relatif à la dissémination volontaire dans l'environnement et à la mise sur le marché de certains produits composés en tout ou partie d'organismes génétiquement modifiés

Arrêté du 5 décembre 2007 suspendant la cession et l'utilisation des semences de maïs MON810

Arrêté du 7 février 2008 suspendant la mise en culture des variétés de semences de maïs génétiquement modifié (Zea mays L. lignée MON 810)

Loi n°2008-595 du 25 juin 2008 relative aux organismes génétiquement modifiés

Cahier des charges concernant le mode de production biologique d'animaux d'élevage et complétant les dispositions des règlements (CE) n° 834/2007 du Conseil et (CE) n° 889/2008 de la Commission (CC FR BIO)

Loi n° 2010-788 du 12 juillet 2010 portant engagement national pour l'environnement (dite loi Grenelle 2)

Arrêté du 16 mars 2012 suspendant la mise en culture des variétés de semences de maïs génétiquement modifié (Zea mays L. lignée MON 810)

Arrêté du 14 mars 2014 interdisant la commercialisation, l'utilisation et la culture des variétés de semences de maïs génétiquement modifié (Zea mays L. lignée MON 810)

Loi n°2014-567 du 2 juin 2014 relative à l'interdiction de la mise en culture des variétés de maïs génétiquement modifié

Arrêté du 15 septembre 2014 relatif aux conditions d'épandage par voie aérienne des produits mentionnés à l'article L. 253-8 du code rural et de la pêche maritime

Loi n° 2016-1087 du 8 août 2016 pour la reconquête de la biodiversité, de la nature et des paysages - Article 125

Arrêté du 4 mai 2017 relatif à la mise sur le marché et à l'utilisation des produits phytopharmaceutiques et de leurs adjuvants visés à l'article L. 253-1 du code rural et de la pêche maritime

Arrêté du 13 juin 2017 approuvant un cahier des charges pour la mise sur le marché et l'utilisation de digestats de méthanisation agricoles en tant que matières fertilisantes

Décret n° 2019-135 du 26 février 2019 modifiant certaines dispositions du code de l'environnement relatives à la dissémination volontaire d'organismes génétiquement modifiés à toute autre fin que la mise sur le marché.

Loi n° 2020-1578 du 14 décembre 2020 relative aux conditions de mise sur le marché de certains produits phytopharmaceutiques en cas de danger sanitaire pour les betteraves sucrières

Arrêté du 5 février 2021 autorisant provisoirement l'emploi de semences de betteraves sucrières traitées avec des produits phytopharmaceutiques contenant les substances actives imidaclopride ou thiamethoxam

Arrêté du 20 novembre 2021 relatif à la protection des abeilles et des autres insectes pollinisateurs et à la préservation des services de pollinisation lors de l'utilisation des produits phytopharmaceutiques

Arrêté du 31 janvier 2022 autorisant provisoirement l’emploi de semences de betteraves sucrières traitées avec des produits phytopharmaceutiques contenant les substances actives imidaclopride ou thiamethoxam et précisant les cultures qui peuvent être semées, plantées ou replantées au titre des campagnes suivantes

6.2.3 Romania

ORDONANȚĂ DE URGENȚĂ Nr. 31/2019 din 14 mai 2019 privind acordarea unor facilități fiscale și pentru modificarea și completarea Legii nr. 227/2015 privind Codul fiscal

ORDONANȚĂ DE URGENȚĂ Nr. 31/2019 din 14 mai 2019 privind acordarea unor facilități fiscale și pentru modificarea și completarea Legii nr. 227/2015 privind Codul fiscal

HOTĂRÂRE nr. 173 din 9 februarie 2006 privind trasabilitatea şi etichetarea organismelor modificate genetic şi trasabilitatea alimentelor şi hranei pentru animale, obţinute din organisme modificate genetic

LEGE nr. 150 din 14 mai 2004 privind siguranţa alimentelor şi a hranei pentru animale

Funded by the European Union

ORDIN nr. 1898 din 20 august 2015 privind organizarea şi funcţionarea Poliţiei Fitosanitare

ORDIN nr. 724/1.082/360/2013 privind atestarea produselor tradiționale

Ordin nr. 1563/2008 pentru aprobarea Listei alimentelor nerecomandate preşcolarilor şi şcolarilor şi a principiilor care stau la baza unei alimentaţii sănătoase pentru copii şi adolescenţi

ORDIN nr. 394 din 12 martie 2014privind atestarea produselor alimentare obţinute conform reţetelor consacrate româneşti

ORDONANȚĂ DE URGENȚĂ nr. 63 din 9 mai 2022 privind unele măsuri temporare pentru acordarea de sprijin material categoriilor de persoane aflate în situații de risc de deprivare materială și/sau risc de sărăcie extremă, suportate parțial din fonduri externe nerambursabile, precum și unele măsuri de distribuire a acestuia

6.2.4 Spain, Andalusia, Asturias, Catalonia, and Navarra

Real Decreto 867/2020, de 29 de septiembre, por el que se regulan los productos zoosanitarios de reactivos de diagnóstico de uso veterinario, los sistemas de control de parámetros fisiológicos en animales y los productos destinados al mantenimiento del material reproductivo animal.

Real Decreto 728/2007, de 13 de junio, por el que se establece y regula el Registro general de movimientos de ganado y el Registro general de identificación individual de animales

Real Decreto 479/2004, de 26 de marzo, por el que se establece y regula el Registro general de explotaciones ganaderas.

Real Decreto 990/2022, de 29 de noviembre, sobre normas de sanidad y protección animal durante el transporte.

Real Decreto 1221/2009, de 17 de julio, por el que se establecen normas básicas de ordenación de las explotaciones de ganado porcino extensivo y por el que se modifica el Real Decreto 1547/2004, de 25 de junio, por el que se establecen las normas de ordenación de las explotaciones cunícolas

Real Decreto 209/2002, de 22 de febrero, por el que se establecen normas de ordenación de las explotaciones apícolas.

Real Decreto 695/2022, de 23 de agosto, por el que se establecen medidas para el control del bienestar de los animales en los mataderos mediante la instalación de sistemas de videovigilancia.

Ley 8/2003, de 24 de abril, de sanidad animal

Ley 32/2007, de 7 de noviembre, para el cuidado de los animales, en su explotación, transporte, experimentación y sacrificio.

Real Decreto 81/2015, de 13 de febrero, por el que se establecen las bases reguladoras de las subvenciones estatales destinadas a las agrupaciones de defensa sanitaria ganaderas

Real Decreto 794/2021, de 14 de septiembre, por el que se establecen las bases reguladoras de las subvenciones a las asociaciones de criadores oficialmente reconocidas por el Ministerio de Agricultura, Pesca y Alimentación para la conservación, mejora y fomento de las razas ganaderas, y se convoca la selección de entidad colaboradora para los ejercicios 2022 a 2025

Real Decreto 1625/2011, de 14 de noviembre, por el que se establecen las bases reguladoras de las subvenciones destinadas al fomento de las razas autóctonas españolas

Real Decreto 505/2013, de 28 de junio, por el que se regula el uso del logotipo "raza autóctona" en los productos de origen animal.

Real Decreto 389/2011, de 18 de marzo, por el que se establecen los baremos de indemnización de animales en el marco de los programas nacionales de lucha, control o erradicación de la tuberculosis bovina, brucelosis bovina, brucelosis ovina y caprina, lengua azul y encefalopatías espongiformes transmisibles

Real Decreto 1201/2002, de 20 de noviembre, por el que se regula la producción integrada de productos agrícolas.

Orden de 10 de octubre de 2007, por la que se aprueba el Reglamento Específico de Producción Integrada de Cultivos Hortícolas Protegidos (tomate, pimiento, berenjena, judía, calabacín, pepino, melón y sandía)

Ley 43/2002, de 20 de noviembre, de sanidad vegetal

Real Decreto 951/2014, de 14 de noviembre, por el que se regula la comercialización de determinados medios de defensa fitosanitaria.

Real Decreto 506/2013, de 28 de junio, sobre productos fertilizantes

Real Decreto 865/2010, de 2 de julio, sobre sustratos de cultivo

Ley 5/2017, de 28 de marzo, de medidas fiscales, administrativas, financieras y del sector público y de creación y regulación de los impuestos sobre grandes establecimientos comerciales, sobre estancias en establecimientos turísticos, sobre elementos radiotóxicos, sobre bebidas azucaradas envasadas y sobre emisiones de dióxido de carbono.

Real Decreto 1178/2008, de 11 de julio, por el que se establecen las bases reguladoras de las ayudas destinadas a las explotaciones ganaderas, las industrias agroalimentarias y establecimientos de gestión de subproductos para la mejora de la capacidad técnica de gestión de subproductos de origen animal no destinados al consumo humano.

Real Decreto 987/2008, de 13 de junio, por el que se establecen bases reguladoras para la concesión de las subvenciones destinadas a determinados proyectos de mejora de la gestión

medioambiental de las explotaciones porcinas.

Ley Foral 7/2013, de 25 de febrero, sobre utilización de residuos alimenticios.

Real Decreto 254/2016, de 10 de junio, por el que se establecen las bases reguladoras de la concesión de ayudas a la cooperación para el suministro sostenible de biomasa en el marco del Programa Nacional de Desarrollo Rural 2014-2020.

Real Decreto 147/2014, de 7 de marzo, por el que se regula la concesión directa de ayudas del Plan de Impulso al Medio Ambiente para la renovación de tractores agrícolas «PIMA Tierra».

Real Decreto 1055/2021, de 30 de noviembre, por el que se establecen las bases reguladoras para la concesión directa de las subvenciones estatales para la renovación del parque nacional de maquinaria agraria.

Real Decreto 1055/2014, de 12 de diciembre, por el que se crea un mecanismo de compensación de costes de emisiones indirectas de gases de efecto invernadero para empresas de determinados sectores y subsectores industriales a los que se considera expuestos a un riesgo significativo de "fuga de carbono" y se aprueban las bases reguladoras de la concesión de las subvenciones para los ejercicios 2014 y 2015.

Real Decreto 113/2022, de 8 de febrero, por el que se establecen las bases reguladoras de las subvenciones para el fomento de acciones de transferencia de conocimientos e información y adquisición de competencias en digitalización, y para el asesoramiento, gestión y sustitución, destinadas al sector agroalimentario, en el marco del Programa Nacional de Desarrollo Rural 2014-2020, y se aprueba su convocatoria para los ejercicios 2022 y 2023.

Orden ICT/738/2022, de 28 de julio, por la que se establecen las bases reguladoras para la concesión de ayudas a actuaciones de fortalecimiento industrial del sector agroalimentario dentro del Proyecto Estratégico para la Recuperación y Transformación Económica Agroalimentario, en el marco del Plan de Recuperación, Transformación y Resiliencia.

Real Decreto 948/2021, de 2 de noviembre, por el que se establecen las bases reguladoras para la concesión de ayudas estatales destinadas a la ejecución de proyectos de inversión dentro del Plan de impulso de la sostenibilidad y competitividad de la agricultura y la ganadería (III) en el marco del Plan de Recuperación, Transformación y Resiliencia.

Real Decreto 637/2021, de 27 de julio, por el que se establecen las normas básicas de ordenación de las granjas avícolas

Real Decreto 1124/2021, de 21 de diciembre, por el que se aprueba la concesión directa a las comunidades autónomas y a las ciudades de Ceuta y Melilla de ayudas para la ejecución de los programas de incentivos para la implantación de instalaciones de energías renovables térmicas en diferentes sectores de la economía, en el marco del Plan de Recuperación, Transformación y Resiliencia.

Resolución 2E/2022, de 14 de enero, de la directora general de Industria, Energía y Proyectos Estratégicos S3, por la que se aprueba la convocatoria de ayudas para la realización de proyectos estratégicos de I+D 2022-2025.

Real Decreto 197/2016, de 13 de mayo, por el que se establecen las bases reguladoras de la concesión de ayudas a la cooperación para planteamientos conjuntos con respecto a proyectos medioambientales y prácticas medioambientales en curso, en el marco del Programa Nacional de Desarrollo Rural 2014-2020.

Ley 3/2001, de 26 de marzo, de Pesca Marítima del Estado

Real Decreto 1044/2022, de 27 de diciembre, de ordenación de la flota pesquera.

Resolución de 28 de abril de 2023, de la Secretaría General de Pesca, por la que se establecen las disposiciones de aplicación del plan de ordenación plurianual del atún rojo en el océano Atlántico oriental y el mar Mediterráneo para 2023

Real Decreto 685/2021, de 3 de agosto, por el que se establecen las bases reguladoras de subvenciones a agrupaciones de entidades que realicen proyectos de inversión y reforma en materia de investigación para el desarrollo tecnológico, la innovación y el equilibrio de la cadena de comercialización en el sector pesquero y de la acuicultura en el marco del Plan de Recuperación, Transformación y Resiliencia, y se convocan para 2021

Real Decreto 1155/2021, de 28 de diciembre, por el que se establecen las bases reguladoras de las subvenciones a agrupaciones de entidades que realicen proyectos en materia de crecimiento azul en el sector pesquero y de la acuicultura, y se convocan para 2022 y 2023.

Real Decreto 854/2021, de 5 de octubre, por el que se establecen las bases reguladoras de las subvenciones para la adquisición e instalación de sistemas de seguimiento electrónico remoto (REM), para el cumplimiento de la obligación de desembarque, para la digitalización de la flota de pequeña escala y para el apoyo al sector pesquero extractivo, acuícola, comercializador y transformador en el marco del Plan de Recuperación, Transformación y Resiliencia, y se convocan para el año 2021.

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Real Decreto 95/2019, de 1 de marzo, por el que se establecen las condiciones de contratación en el sector lácteo y se regula el reconocimiento de las organizaciones de productores y de las organizaciones interprofesionales en el sector, y por el que se modifican varios reales decretos de aplicación al sector lácteo.

Real Decreto 989/2022, de 29 de noviembre, por el que se establecen normas básicas para el registro de los agentes del sector lácteo, movimientos de la leche y el control en el ámbito de la producción primaria y hasta la primera descarga

Real Decreto 153/2016, de 15 de abril, sobre declaraciones obligatorias a

efectuar por los fabricantes de leche líquida envasada de vaca.

Real Decreto 319/2015, de 24 de abril, sobre declaraciones obligatorias a efectuar por primeros compradores y productores de leche y productos lácteos de vaca, oveja y cabra.

Ley 2/2000, de 7 de enero, reguladora de los contratos tipo de productos agroalimentarios

Real Decreto 237/2000, de 18 de febrero, por el que se establecen las especificaciones técnicas que deben cumplir los vehículos especiales para el transporte terrestre de productos alimentarios a temperatura regulada y los procedimientos para el control de conformidad con las especificaciones.

Real Decreto 1021/2022, de 13 de diciembre, por el que se regulan determinados requisitos en materia de higiene de la producción y comercialización de los productos alimenticios en establecimientos de comercio al por menor.

Real Decreto 30/2009, de 16 de enero, por el que se establecen las condiciones sanitarias para la comercialización de setas para uso alimentario.

Ley 12/2013, de 2 de agosto, de medidas para mejorar el funcionamiento de la cadena alimentaria

Real Decreto 1028/2022, de 20 de diciembre, por el que se desarrolla el Registro de Contratos Alimentarios.

Ley Foral 17/2001, de 12 de julio, reguladora del comercio en Navarra

Decreto 32/2003, de 30 de abril, de ordenación de la actividad de restauración.

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Real Decreto 1799/2010, de 30 de diciembre, por el que se regula el proceso de elaboración y comercialización de aguas preparadas envasadas para el consumo humano.

Real Decreto 949/2021, de 2 de noviembre, por el que se establecen las bases reguladoras para la concesión de subvenciones destinadas a inversiones en materia de bioseguridad para la mejora o construcción de centros de limpieza y desinfección de vehículos de transporte por carretera de ganado, así como para inversiones en bioseguridad en viveros, acometidas por determinados productores de materiales vegetales de reproducción, en el marco del Plan de Recuperación, Transformación y Resiliencia.

Orden APA/925/2007, de 3 de abril, por la que se establecen las bases reguladoras para la concesión de subvenciones para planes de asistencia técnica en los sectores agroalimentarios, acogidas al Reglamento (CE) 1998/2006, de la Comisión, de 15 de diciembre de 2006, relativo a la aplicación de los artículos 87 y 88 del Tratado a las ayudas de «minimis»

Real Decreto 190/2007, de 9 de febrero, por el que se establecen las bases reguladoras de las ayudas «de minimis» destinadas a la implantación de sistemas de autocontrol en los mercados de Ganado

6.2.5 Sweden

V-Label International

Djurskyddslag

Arlagården version 4.0

Djurskyddsförordningen

Djurskyddsbestämmelserna

Statens jordbruksverks föreskrifter och allmänna råd om biosäkerhetsåtgärder samt anmälan och övervakning av djursjukdomar och smittämnen;

Förordning (2009:1394) med instruktion för Statens veterinärmedicinska anstalt

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Epizootilag (1999:657)

Zoonoslag (1999:658)

Statens jordbruksverks föreskrifter om läkemedel och läkemedelsanvändning

Lag (2006:806) om provtagning på djur, m.m.

Gröna nyckelhålet

KRAV -hållbar livsmedelsproduktion

6.3 Individual reports of each institution involved in the Deliverable 2.1

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consortium

WAGENINGEN UNIVERSITY & RESEARCH
AKI Institute of Agricultural Economics
APRE Agenzia per la Promozione della Ricerca Europea
copa*cogeca european farmers european agri-cooperatives
DANONE ONE PLANET. ONE HEALTH
ECOZEPT
EuroCARE AGRICULTURAL POLICY RESEARCH
INRAE science for people, life & earth
LOBA®
AARHUS BSS MAPP CENTRE – RESEARCH ON VALUE CREATION IN THE FOOD SECTOR DEPARTMENT OF MANAGEMENT AARHUS UNIVERSITY
MVO NEDERLAND
PEDAL CONSULTING
National Institute for Public Health and the Environment Ministry of Health, Welfare and Sport
SLU SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES
sustainable member of denkstatt group
UNIVERSIDAD DE ALMERÍA
TECHNISCHE HOCHSCHULE NÜRNBERG GEORG SIMON OHM
ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA
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@FOODCoSTEU

Report on policies with internalised externalities at the EU, national and regional levels

D2.1

Individual report on French public policies

INRAE, Toulouse School of Economics

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Deliverable 2.1

Individual report on French public policies

Deliverable type

Individual report

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1 Chemical safety & biosafety

1.1 Pesticides

Key findings

- Pesticides, which are widely used in modern agriculture, cause significant environmental and health issues, with a social cost in France estimated to be €372 million. They lead to soil, water and air pollution, loss of biodiversity and health risks, including acute and chronic diseases such as cancer.

- In response to the negative impacts of pesticides, France has implemented the Ecophyto II+ plan, in order to meet a target of a 50% reduction in the use of pesticides by 2025 through a combination of regulatory and market-based instruments. The policy instruments include a pesticide tax on diffuse pollution levied on the sale of pesticides and bans on hazardous substances such as neonicotinoids.

- A tax on pesticides in the agricultural sector, based on the "polluter pays" principle, can be an effective strategy to address environmental impacts. Differentiated tax rates on substances that pose significant risks encourage substitution towards less harmful products, potentially encouraging a shift towards more sustainable agricultural practices.

- The introduction of pesticide taxes could increase production costs for farmers, affecting their profitability. The effectiveness of these taxes in reducing pesticide use depends on price elasticities, which are generally found to be low. The tax incentivizes the adoption of more costly alternative pest management methods and could affect crop yields.

- The pesticide tax has led to reduced consumption of hazardous chemical pesticides in France and other EU countries. While the causal effect of the tax on externalities has not been evaluated, this tax has shown potential in reducing the impact of pesticides on biodiversity and contributing to national policy objectives like climate change mitigation. However, the tax could also have a negative impact on farmers' income levels, especially in the short term.

- Neonicotinoids, widely used in agriculture, have been linked to declines in pollinator populations and adverse effects on other non-target organisms due to their persistent toxicity and environmental dispersion. To protect biodiversity and food systems, the European Union and France have taken regulatory measures, including banning certain neonicotinoids (NNIs).

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Despite these bans, temporary exemptions have been granted in some crisis situations, such as the outbreak of the mild yellow virus in France, highlighting the ongoing complexities in balancing agricultural needs and environmental protection.

- A neonicotinoid ban might increase production costs, change pest management strategies, and affect market dynamics. These impacts are mainly driven by the complex potential impacts on yields, consumer prices, willingness to pay for neonicotinoid-free products, and impacts on other sectors. In particular, substitution of harmful pesticides could offset environmental gains, while alternative pest management practices could mitigate potential financial impacts.

- The neonicotinoid ban could increase biodiversity and promote sustainable agriculture, but it could also affect farmers' incomes, and food safety. Impacts on human health, both direct and indirect, must also be considered. The results of the ban will depend heavily on the substitution choices made by farmers after the ban.

Pesticides are chemical or biological substances used to control harmful pests such as weeds and pathogens that pose a risk to crops and humans (Oerke, 2006). Nowadays, pesticides have become a fundamental component of modern agricultural practices (Tilman et al., 2002), contributing significantly to increasing productivity, ensuring global food security, and preventing the spread of vector borne diseases (Sexton et al., 2007). In an extensive review, Cooper and Dobson (2007) summarize the many benefits of pesticides in agricultural production.

Nonetheless, starting with the publication of Carson (2000)'s Silent Spring, which highlighted the risks of pesticide use, there has been steady progress in documenting the public health and environmental costs resulting from the continued use of chemical inputs (Pimentel et al., 1992; Pimentel and Greiner, 1997). Excessive and inappropriate use of pesticides could also lead to negative externalities for society, for example, related to environmental degradation, including runoff, leaching, and nutrient surpluses[1] resulting in contamination of soil, water, and air (Pimentel et al., 1992; Pimentel and Greiner, 1997; Mourato et al., 2000; European Commission, Directorate General for Agriculture and Rural Development, and EEIG Alliance Environnement, 2020). Further, pesticides have been identified as a major driver of biodiversity loss over the last three decades (Schmeller and Bridgewater, 2016), exerting pressure on ecosystems and affecting non-target organisms such as plants, insects (e.g. bees and other pollinators), birds, mammals and amphibians (Pimentel et al., 1992; Köhler and Triebskorn, 2013; Carvalho, 2017; Matthews, 2015; Medarova-Bergstrom, 2015).

From a public health perspective, pesticides are potentially toxic to humans and can cause both acute and chronic health effects, depending on the level and route of exposure (FAO, 2022) to the users (i.e. farmers) and the general public (Mourato et al., 2000; Batsch, 2011). People who face the greatest health risks from exposure to pesticides are those who come into contact with them at work, in their homes, or in their gardens (FAO, 2022). Direct mechanisms of occupational exposure include dermal, respiratory, oral, and ocular exposure. Tens of thousands of farmers worldwide are exposed to pesticides each year, with the majority of poisonings and deaths (Leon et al., 2011; Laurent et al., 2016; Garrigou et al., 2020). Moreover, as they disperse in the environment after application, pesticide residues or metabolites are sometimes detected and can potentially be transferred in water and food supplied to consumers (Craddock et al., 2019; ANSES, 2023; Cabrera et al., 2023). A recent report by Inserm (2021) identifies a range of human diseases and disorders associated to pesticides, including various cancers, respiratory disorders, diabetes, Parkinson's disease, leukemia, mental disorders, and neurological diseases, among others.

The true social cost of these pollutants in France is estimated to be €372 million according to Alliot et al. (2022). Balancing the benefits and adverse effects of pesticide

[1] One of the main environmental concerns are nitrogen and phosphorus runoff from excessive fertilization, intensive livestock farming and pesticide use. The nutrient surplus, equal to input minus output in products and manure removed, results in nitrogen and phosphorus losses to soil and atmosphere.

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use is a major challenge in regulating pesticide practices, and stepping off the track of pesticide dependence, for sustainable agriculture.

In France, reducing the use of phytosanitary products is a major public expectation and a priority for preserving our health and biodiversity. The Ecophyto II+ plan embodies the commitments made by the French government and provides an impetus to achieve the goal of reducing pesticide use by 50% by 2025 (Ministère de l'Agriculture et de la Souveraineté alimentaire, 2022).[2] The French government is actively addressing these risks associated with pesticide use through a range of regulatory and market-based instruments (OECD, 2013). These policy instruments include a **pesticide tax on diffuse pollution**, which accounts for the risk premia of different pesticides (Finger et al., 2017), and **bans on hazardous substances**, particularly **neonicotinoids** (NNIs), which are recognized for their harmful effects on pollinators and ecosystems.

1.1.1 Pesticide tax

1.1.1.1 Introduction

Environmental taxes provide a strategic approach to mitigating the harmful effects of various pollutants, such as pesticides. Based on the Pigouvian theory, these taxes are designed to internalize the external costs of environmental degradation, thereby aligning market prices with their corresponding social costs (Pigou, 1920). The goal is to impose costs on the excessive consumption of harmful substances, thereby stimulating behavioral changes among producers and consumers (Sud, 2020). This principle, known as the ”polluter pays” principle, aims to make polluters pay for the costs of their pollution, either by reducing their emissions or by compensating for the damage (Bénassy-Quéré et al., 2017). Nevertheless, the designing of an effective environmental tax requires an accurate assessment of the tax base, which is often a difficult task given the complexity of quantifying the different impacts of pollution (Chiroleu-Assouline, 2015). Taxes can be differentiated to reflect the heterogeneity of environmental impacts associated with different substances and contexts (Lefebvre et al., 2015). Policymakers also need to consider potential consequences, such as increased use of less hazardous but higher-dose pesticides, when implementing highly differentiated tax systems (Böcker and Finger, 2016). Despite these challenges, environmental taxes are seen as a valuable tool for aligning economic behavior with environmental goals, a philosophy increasingly embraced within the EU policy framework. However, their effectiveness depends heavily on the precision of their implementation (OECD, 1972, 2017a).

[2] The Ecophyto II+ plan meets the *Green Deal* objectives and an European obligation set out in Directive 2009/128/EC establishing a framework for Community action to achieve a sustainable use of pesticides, which requires Member States to "adopt national action plans setting out their quantitative objectives, targets, measures and timetables to reduce the risks and impacts of pesticide use on human health and the environment and to encourage the development and introduction of integrated pest management and alternative methods or techniques to reduce dependence on pesticide use" (Ministère de l'Agriculture et de la Souveraineté alimentaire, 2022).

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For the agricultural sector, a tax on polluting inputs is a recent strategy and can be a way to address environmental and health impacts, especially water pollution (OECD, 2023). Pesticide taxes can be categorized into different types, including uniform taxes, and differentiated rates. Uniform taxes, implemented on an ad valorem or per-volume basis of active substances, do not account for varying pesticide exposure or the level of toxicity (Söderholm, 2009). On the other hand, differentiated rates impose a higher burden on substances that pose more environmental and health risks, thus encouraging a shift towards lower-risk alternatives. Despite their potential, the use of taxes within regulatory frameworks for fertilizer and pesticides remains limited. The efficiency of a tax depends on its type, its design (proportional or progressive), its level and its transmission along the food chain. Differentiated tax schemes require fewer complementary policy measures to attain policy goals (Böcker and Finger, 2016).

In Europe, only a few countries have levied taxes on these pollutants beyond the general form of ad-valorem taxes with a clear intent to reduce pollution. This tax system has been adopted for pesticide taxes in Sweden (1984), Norway (1988, redesigned in 1999), Denmark (1996, redesigned in 2013), France (redesigned in 2008), and Mexico (2014) (Sud, 2020). The Nordic countries are pioneers in this application, particularly Norway and Denmark, which have established sophisticated tax systems that take into account the toxicity of the products to humans and the environment. In Denmark, the tax system is notable for its complexity, as it supplements a base rate per active ingredient with factors such as toxicity, soil degradability, bioaccumulation and leaching potential, collectively referred to as "environmental fate".

1.1.1.2 Pesticide tax in France

France is the world's third largest and Europe's largest consumer of pesticides. However, France has experienced a significant shift in pesticide use in recent decades.[3] In 2004, the country's sales totaled 76,100 tons of active substances (AS)[4], mainly fungicides (49%) and herbicides (34%) (Aubertot et al., 2005). In line with the European Green Deal and the national plan Ecophyto II+, the country has experienced a decline in sales of AS over the last decade, with 43,013 tons sold in 2021 (19% below the 2012-2017 average), according to provisional aggregate sales data published in SDES (2023). This downward trend, accompanied by a 13% increase in sales of products for biological control and organic farming between 2020 and 2021, indicates a clear shift towards more sustainable agricultural practices. In parallel, the share of substances classified as carcinogenic, mutagenic, and toxic to reproduction (CMR) decreased from 27% to 11%, and there was an 85% reduction in high-risk substances (CMR1) between 2018 and 2021. Despite the improved technical efficacy (especially in specialized production systems with high yield

[3] Despite the commitment to integrated pest management articulated in the Pesticide Framework Directive 2009/128/EC by European pesticide policy, pesticide usage and correlated risks have not declined over the past decade. The yearly consumption of active substances in the EU persistently hovers around 380,000 tons (European Court of Auditors, 2020; JRC et al., 2020).

[4] This figure excludes products for use in organic farming and biocontrol products.

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objectives, see Aubertot et al. (2005)) and reduced doses of modern pesticides, these figures mask French agriculture's continued reliance on pesticides and the escalating environmental and public health risks. These chemicals often contaminate the country's ecosystems (Pimentel et al., 1992; Pimentel and Greiner, 1997; Mourato et al., 2000; European Commission, Directorate General for Agriculture and Rural Development, and EEIG Alliance Environnement, 2020). In recent decades, the issue of water pollution from pesticides has especially become a major concern in France. Despite strict EU regulations aimed at curbing pesticide pollution[5], nearly 20% of surface water monitoring stations reported exceeding the maximum or average annual authorized concentration for at least one pesticide during the period 2017-2019 in France (Ministère de la Transition Ecologique, 2022). This underscores the need for effective national strategies to address the problem, such as the introduction of a pesticide tax.

The first tax applied to plant protection products in France was instituted by the Finance Act for 1999 under the framework of the General tax on polluting activities (*Taxe générale sur les activités polluantes*, TGAP).[6] The purpose of this tax is to combat air pollution and the emission of waste or products that cannot be easily absorbed by the environment. Based on the polluter-pays principle, the tax had two stated objectives: to provide an incentive to industry to develop fewer toxic alternatives and to provide an incentive for farmers to purchase and use fewer toxic products. The TGAP was then paid by companies whose activities or products are deemed to cause pollution and was collected from 12,000-13,000 distributors in the case of pesticides (Böcker and Finger, 2016). The tax is calculated as the weight of classified hazardous substances used in the composition of products. These substances are divided into seven categories, each assigned a specific unit rate (from 0 to €1677/ton) according to their ecotoxicological and toxicological characteristics (MAP, 2016; Böcker and Finger, 2016). The TGAP on pollution had been criticized for its low rates, providing little incentives (Chiroleu-Assouline, 2015) and its small amount of revenue (€59 million in 2016, i.e. far below the pesticide prices).

In 2008, the TGAP on pesticides was replaced by a tax on diffuse agricultural pollution (*Redevance pour pollutions agricoles diffuses*, RPD) with an entry into force of the **Law No. 2006-1772** of 30 December 2006 relative to water and the freshwater environment *(Loi sur l'eau et les milieux aquatiques)*. Unlike the TGAP, the tax on diffuse pollution is levied on the sale of pesticides, as a fee on the invoice collected by distributors but paid at the retail level by customers of plant protection products or seeds treated with such products (i.e. farmers). This strategy increases the visibility of the tax to farmers, thereby raising awareness (Oskam et al., 1998) of the need to reduce the environmental and

[5] The existing EU legislation imposes a protective framework with standards for all water bodies in EU countries and addresses specific pollution sources, including agricultural pollution. The three main directives involved are the Water Framework Directive (WFD) (2000/60/EC) (on water resources management), the Nitrates Directive (91/676/EEC) and the Floods Directive (2007/60/EC). The 2006 Water and Aquatic Environment Act relates to water pollution, the modernization of collection networks, diffuse pollution, abstraction, storage in low-water times, barriers on watercourses and protection of the aquatic environment.

[6] The TGAP is not included in our database since this policy is targeting manufacturers and importers (i.e. outside our scope of analysis for WP2.1 of Foodcost project).

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health risks posed by hazardous substances in phytopharmaceutical products (OECD, 2011; Bommelaer and Devaux, 2012).[7] The new pesticide tax is a combination of a tax base and a AS-specific tax rate and is calculated as follows:

$$Fee = Base \times Tax\,rate$$

where the tax base corresponds to the quantity of classified active substances sold to end-users during the year. The list of AS subject to the RPD is specified by ministerial order (MAP, 2010,2022). The RPD, together with six other water taxes, is divided into three different pesticide categories according to the dangerousness and toxicity of the AS. The tax rates are €5.10/kg for substances that are toxic, very toxic, carcinogenic, mutagenic, or teratogenic (i.e. likely to cause birth defects in children exposed *in utero*); €2/kg for substances harmful to the environment: and €0.90/kg for mineral chemicals harmful to the environment.

The revenue from the non-point source pollution charge collected by the water agencies reached €188.7 million in 2021 (€96.9 million in 2020 and €139.2 million in 2019, excluding the €41 million dedicated to the Ecophyto program) (République Française, 2022). The levy is used to finance projects implemented by local authorities or the agricultural sector, i.e. individual measures for farmers (agri-environmental and climate measures, aid for organic farming, investment aid, aid for strategic advice) and collective measures (aid for coordination, aid for sectors) (République Française, 2022).

1.1.1.3 Mechanisms of the instrument for internalization

Figure 1.1 illustrates the pathways of effects from the implementation of a pesticide tax to changes on health, social and environmental externalities. The impact of this fiscal measure depends on several factors, such as the design of the tax, the structure of the incentives created, the tax rate adopted, the price elasticity of demand and the precision of targeting to specific sectors or activities. The use of tax revenues, the influence on public awareness and the signaling function of taxes are other important impact channels (Skou Andersen, 2016; OECD, 2011,2023).

[7] Until 2011, the distributor/seller of phytosanitary products was the only person liable for the diffuse pollution tax. From 2012, the new article L.254-3-1 of the Rural Code makes the purchaser of the products liable if he receives them from a person who is not liable herself. The sale of seeds treated with phytosanitary products will be included in the tax system. In the case of the purchase of products or treated seeds abroad, contract sorters and farmers are also liable and, in this context, are required to submit a report on their foreign purchases.

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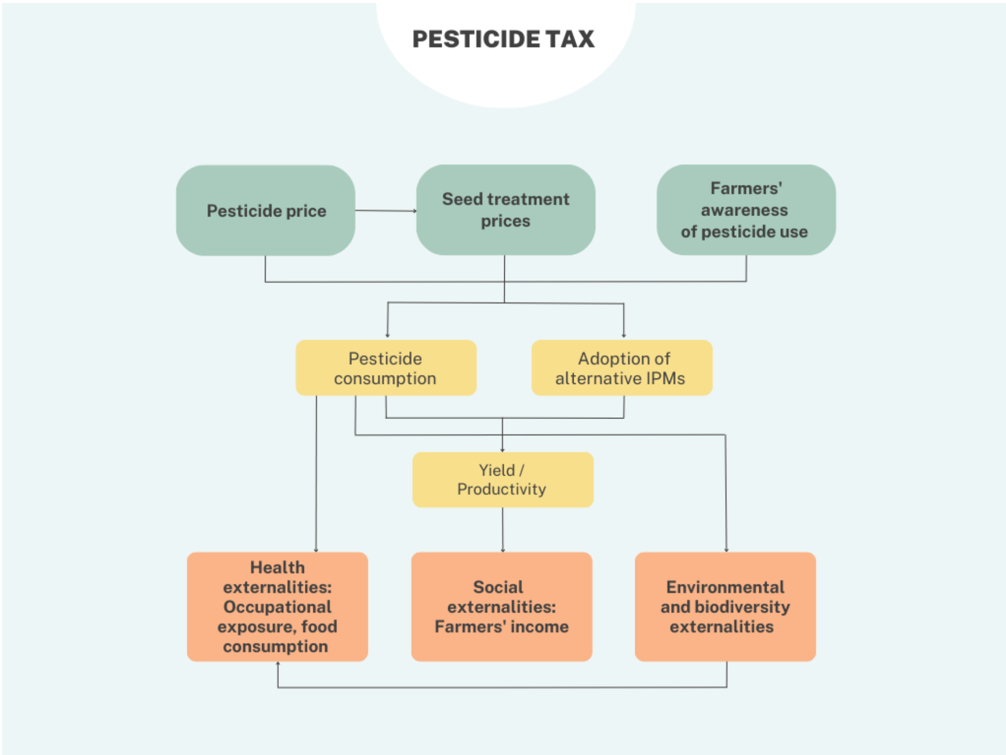

Figure 1.1: Pathways of Effects

1.1.1.3.1 Impact on production costs

Pesticide taxes are often opposed by producers because of their potential to increase production costs (Buchanan and Tullock, 1962). This cost increase is attributed to the direct impact of the tax, the potential reduction in pesticide use it may induce, the subsequent shift to more costly alternative pest management methods, as well as the effect on yields.

1.1.1.3.1.1 Direct effect on pesticide price

A key concern for farmers is the cost of purchasing pesticide, which accounts for approximately 15% of operating costs in EU (Skou Andersen, 2016) and 8.25% in France (Chakir and Thomas, 2022). In 2017, the tax on pesticides represented between 5% and 6% of the pesticide sales price on average (OECD, 2017b). This is significantly lower than in Denmark, where the tax represents 54% of the sales price for insecticides and 34% for other crop protection products (SEEID, 2017). To date, Nielsen et al. (2023) is the first and only analysis that has provided insight into the impact of the pesticide tax, thereby bridging the research gap on *ex post* evaluations of environmental taxes. The authors show that the Danish pesticide tax, considered the most sophisticated currently in place, was redesigned in 2013 to differentiated tax rates according to the harmfulness of the products, significantly increasing the cost of the most toxic pesticides.[8]

1.1.1.3.1.2 Decrease in pesticide consumption

In the previous sections, we provide evidence from the literature that the introduction of a pesticide tax can increase the input prices, and that the magnitude of the increase depends on the design of the tax. Assuming that farmers act as rational profit maximizers, the effectiveness of pesticide taxes in reducing the use of harmful products depends on several factors, including price elasticities that vary by product type, time period, and the type of farming (Falconer and Hodge, 2000; Böcker and Finger, 2017). In the case of pesticides, research confirms negative own-price elasticities of demand for pesticides, indicating that demand for certain pesticides is generally low meaning that farmers are not very responsive to pesticide price increase. In other words, a tax would have a limited effect on the demand for the polluting good. A meta-analysis by Böcker and Finger (2017) finds a median own-price elasticity of -0.28. This means that a 1% tax increase is estimated to reduce the demand for pesticide inputs by 0.28%, confirming that it is highly unlikely that water pollution from these inputs can be addressed by taxation alone. Limited responsiveness is particularly evident in the short term, mainly due to the challenges and costs associated with abatement or product substitution of good alternatives to pesticides under current constraints (Böcker and Finger, 2017; Finger et al., 2017; Eeva, 2023). **For the case of France**, Jacquet et al. (2011) find an elasticity of -0.77 (ranging from -1.25 to -0.28), while Femenia and Letort (2016) find a value of -0.17 (ranging from -0.24 to -0.10). The literature review by Skevas et al. (2013) provides an own-price elasticity for pesticides consistent with those for Europe (Böcker and Finger, 2017), recently confirmed by Chakir and Thomas (2022) with a value of -0.37. These results suggest that current agricultural production practices in Europe and in France are still dependent on the use of pesticides despite the implementation of a tax and other regulatory policies.

Although demand for pesticides is relatively inelastic in the short run, own-price demand elasticities are assumed to be higher in the long run, given that reactions and substitutions take more time to take effect. In this context, taxes may reduce usage over time (Aubertot et al., 2005) and provide a continuing incentive for innovation (Eeva, 2023).

As a result, given the low price elasticity of pesticides, the tax does not directly reduce externalities. Instead, it serves as a mechanism to incorporate the cost of these externalities into the price as long as the pass-through rate is greater than zero.

[8] The Danish pesticide tax is a combination of a pesticide use and a pesticide risk indicator and is calculated as follows (presented for a liquid product) (Böcker and Finger, 2016):

Tax in DKK/1 = exposition tax + toxicity tax

$$= \frac{DKK}{1} \times X \frac{kg\ AS}{1} + \sum_{i=1}^{3} \frac{DKK}{1} \times factor_i L$$

1.1.1.3.1.3 Substitution toward alternative methods

The influence of an environmental tax on agricultural practices largely hinges on the extent of **substitution** among various pesticides employed in farming.

By changing the relative costs between chemicals of concern and their less harmful alternatives, the tax provides a constant incentive for substitution and investment (OECD, 2010; Rusu et al., 2021) as long as the marginal cost of substitution remains below the cost of using those chemicals. In the long run, the tax may offer potential benefits if it encourages a shift to more sustainable agricultural practices. The success of this transition depends on several variables, including the adaptability of farmers, market dynamics, and overarching agricultural policies (Gren, 1994). Nevertheless, the transition to more environmentally friendly practices may entail additional costs, such as education, training, and implementation, which could further affect the economic performance of farmers. According to Skevas et al. (2013) and Böcker and Finger (2017), farmers may have few substitutes, or the alternatives may be costly or ineffective. Still, differentiated taxes have led to substitution towards less toxic products and nonchemical strategies (Böcker and Finger, 2016). Using a panel dataset of pesticide use on 1,900 medium and large farms two years before and four years after the Danish tax change, Nielsen et al. (2023) find that the tax effectively encourages a shift from more harmful to less harmful products, leading to an average 16% reduction in pesticide use between 2012 and 2017.

1.1.1.3.1.4 Effect on yields and productivity

The impact of a pesticide tax on yields depends primarily on **two factors**: the **direct decrease in pesticide use** and the subsequent **adoption of environmentally friendly alternatives**. However, the literature provides mixed results on the true effect of this tax policy on yields.

Directly, the tax has motivated a decrease in pesticide consumption, but this has led to an increased risk of pest outbreaks, weeds and diseases, which subsequently pose challenges to crop yield optimization (Oerke and Dehne, 2004; OECD, 2007b; Savary et al., 2012,2019; Oliveira et al., 2014). Without their conventional chemical methods, farmers have been forced to face these challenges either in the field (pre-harvest) or later during storage (post-harvest), which has inevitably led to yield variability depending on the severity of the pest or disease outbreak and the crop's inherent resistance (Finger et al., 2017), environmental conditions, crop species grown, farming practices, socioeconomic conditions of farmers, and the level of technology used (Oerke and Dehne, 2004; Oliveira et al., 2014). However, The low elasticity of pesticide demand results in either a small negative impact or no impact at all after the implementation of a pesticide tax, as demonstrated by Ørum et al. (2019) in Denmark.

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On the other hand, the transition towards more sustainable practices, such as integrated pest management, biological control agents, and precision agriculture, has shown uncertainty in maintaining and, in some cases, increasing crop yields. However, the success of these methods depends on several factors, including the specific crop, pest dynamics, local agro-climatic conditions, and farmer expertise to implement the methods effectively. It is important to note that these alternative methods often require a steeper learning curve and may take longer to produce results, resulting in a period of potential yield loss. Furthermore, the inherent yield variability resulting from reduced pesticide use and the transition period to alternative methods has the potential to disrupt the predictability of production output, leading to greater financial risks for farmers (Popp et al., 2012). Lechenet et al. (2017) contrast these findings, stating that increased adoption of sustainable techniques such as integrated pest management and precision agriculture could also help offset yield losses. This yield variability can have broader impacts on the global supply chain and market prices, further affecting production costs (Finger et al., 2017).

In their review of research from 1963 to 1991, Bourguet and Guillemaud (2016) note that a benefit-cost ratio of 4 is often cited, reflecting the marginal agricultural productivity of pesticide use relative to its purchase cost. This result suggests that the introduction of a pesticide tax may result in a loss of productivity if the increase in cost is not offset by factors such as subsidies or higher market prices (Aubertot et al., 2005).

In conclusion, the pesticide tax has ambiguous effects **on global production costs**. The pesticide tax may increase crop protection costs, forcing farmers to reduce pesticide use and accept higher upfront costs for sustainable alternatives, temporarily increasing production costs. This potential reduction in pesticide use may disrupt yields and impose financial risks on farmers, although the adoption of sustainable techniques could offset these losses. Such yield variability may affect global supply chains and market prices, further impacting production costs. However, the literature suggests a low elasticity for pesticide demand, which implies that the impacts of the pesticide tax on production costs could be smaller than expected, or even unsignificant.

1.1.1.3.2 Pass-through to price

Like any other sin tax, a pesticide tax has **distributive effects** and the potential to affect food prices, largely through its impact on the production costs of agricultural products. To date, there have been no *ex-ante* evaluations of the impact of the 2008 tax on market prices, but it is likely to have been modest given the design of the fee and its relatively low level.

After incurring higher costs due to the pesticide tax, farmers are likely to pass these additional costs on to consumers in order to maintain their profitability levels. However, the pass-through rate may vary as it may depend on strategic pricing decisions made by farmers, which may under- or over-transmit these additional costs into food prices. Over-shifting, where prices increase by more than the tax amount (pass-through rate greater than 1), may be desirable, while under-shifting, where farmers and retailers absorb part of tax (pass-through rate lower than one), is less desirable.

The pass-through rate depends on a variety of factors. Market dynamics, supply and demand elasticities, competitiveness within the agricultural sector, and policy interventions such as subsidies or trade barriers all play a role in determining the pass-through rate. The impact of the pesticide tax on food prices also depends on farmers' behavioral responses to the tax. If farmers reduce their use of pesticides or switch to more expensive but environmentally friendly alternatives, the resulting increase in production costs may increase the upward pressure on food prices. However, if farmers adopt innovative practices to maintain yields while reducing pesticide use, or if they receive subsidies to offset the increased costs, the impact on food prices may be mitigated.

1.1.1.3.3 Public awareness and political economy considerations

Societal acceptance of a pesticide tax depends on several concerns, mainly related to the environment, the competitiveness of the agricultural sector, and potential increases in consumer prices for agricultural products. Both farmer and consumer understanding and awareness play a critical role in the effectiveness and optimization of these taxes.

For **farmers**, the introduction of a pesticide tax can promote a sense of social responsibility, leading them to consider and adopt less harmful alternatives such as biopesticides or sustainable farming practices (Skou Andersen, 2016; Söderholm and Christiernsson, 2008; UNDP, 2017) and stimulate innovation (Lefebvre et al., 2015). However, this policy change often faces opposition from farmers (Skou Andersen, 2016), indicating the need for strategic management by policymakers. Ensuring farmers' global competitiveness amid the introduction of this tax requires well-planned revenue redistribution strategies.

1.1.1.4 Policy impacts on externalities

The intensive use of pesticides is associated with adverse effects on the environment and human health (Böcker and Finger, 2016. As discussed above, the pesticide tax in France has reduced the consumption of hazardous chemical pesticides, albeit at a low level (Chakir and Thomas, 2022). Furthermore, the tax could indirectly improve health by encouraging the adoption of more environmentally friendly agricultural practices, thereby reducing overall pollution and its subsequent health effects.

To date, the isolated effect of the pesticide tax on externalities has not been evaluated *ex post*, making it difficult to assess the tax as a success or failure. More comprehensive research is required to thoroughly assess the impacts and effectiveness of such a tax. Nevertheless, valuable insights can be gleaned from analogous studies conducted in European countries.

1.1.1.4.1 Impacts on environmental and biodiversity externalities

Similar to fertilizers (Söderholm and Christiernsson, 2008), assessing the short-run environmental impact of pesticide taxes is complicated because the taxes levied are not proportional to global environmental damage. Therefore, a low-price response may result in only a small reduction in pesticide use unless taxation is increased substantially. According to studies in Norway and Sweden, these taxes have led to a shift towards less harmful pesticides, resulting in reduced risks to both the environment and human health (Bragadottir et al., 2010; Böcker and Finger, 2016). For example, the Swedish pesticide risk indicator shows a significant reduction in environmental risks, which cannot be attributed solely to pesticide taxes, but there is a clear correlation (Böcker and Finger, 2016). Indeed, these taxes have encouraged more sustainable pest management strategies, indirectly reducing reliance on harmful chemical pesticides (Assey et al., 2021). In terms of biodiversity, studies have shown that pesticides can have devastating impacts on a wide range of species, from aquatic communities to wild bees and birds (Relyea and Hoverman, 2006; Brittain et al., 2010; Beketov et al., 2013; Assey et al., 2021). Consequently, a tax on pesticides could indeed alleviate this issue by encouraging a shift to less harmful alternatives, thus benefiting biodiversity.

However, as the tax could lead to a reduction in crop yields, the environmental and biodiversity benefits of the tax could then be reduced due to substitution by other crops and/or expansion of land area.

It is also important to note that pesticide residues are often persistent in the environment, which can have long-term negative effects on ecosystems and wildlife. Despite the introduction of a pesticide tax, France is still experiencing high levels of pesticide pollution due to increased use (OECD, 2016), indicating the need for further measures beyond taxation.

Finally, such fiscal instrument could also contribute to other national policy objectives, including climate change, by helping to reduce GHG emissions from the agricultural sector. Outside the EU, however, taxing pesticides would have a negative impact on the climate due to changes in land use outside the EU (Bareille and Gohin, 2020).

1.1.1.4.2 Impacts on social and health externalities

1.1.1.4.2.1 Impact on public health

By discouraging the overuse of harmful pesticides (Bragadottir et al., 2010), the pesticide tax could play a role in **mitigating associated health risks**. However, quantifying the exact impact of pesticides on human health is complex because of the delay between exposure and the onset of health problems. Several factors, such as occupational exposure for farmers and households and dietary habits, influence health effects.

Many studies suggest that reduced use of hazardous pesticides could lead to reduced health risks for workers in the agricultural sector (Moore and Villarejo, 1995; Laurent et al., 2016). Further, underreporting of chronic diseases resulting from prolonged pesticide exposure has been a noted concern.

Moreover, pesticide taxes could encourage a shift to safer agricultural practices, resulting in safer food with lower levels of pesticide residues. This could lead to health benefits for consumers as well as economic benefits in the form of reduced health care costs (Alliot et al., 2022).

1.1.1.4.2.2 Impact on social externalities

In terms of social externalities, pesticide taxation can also have a direct impact on **income** levels, especially in the short run (Pedersen et al., 2011). Studies by Oskam et al. (1992) and Aaltink (1992) indicate that even modest increases in pesticide prices can lead to significant income losses, particularly in sectors with high pesticide use. Moreover, Falconer (2001) notes that the impact of pesticide taxation on farmer income depends on the specific tax instrument used and the trade-offs between environmental policy and farm income. This reduction in income is compounded by potential yield losses due to changes in pesticide use, which can affect farm profitability in the short run.

1.1.2 Ban of Neonicotinoids in France

1.1.2.1 Introduction

Neonicotinoids (NNIs) are widely used in agricultural practices and pest management (Simon-Delso, 2014). The five main active ingredients in products registered for plant protection are **imidacloprid, clothianidin, thiamethoxam, thiacloprid and acetamiprid**, which are mainly used in field crops (especially seed treatment), arboriculture, vegetables, and ornamentals. Over the past two decades, NNIs have come under scrutiny for their potential role in the decline of bee populations[9], dying off or seemingly abandoning their hives colony collapse disorder – a phenomenon known as Colony Collapse Disorder (USDA Agricultural Research Service, 2014). The effects of NNIs extend beyond bees and encompass other non-target organisms such as additional pollinators (e.g. butterflies), insect predators (e.g. birds, mice, moles, field mice, and bats), and soil-enriching organisms like earthworms. These concerns stem primarily from the inherent properties of NNI, including their poor biodegradability, persistent toxicity that can last up to three years, and ability to disperse in the environment through processes such as soil migration and groundwater contamination (Dewar and Qi, 2021). In addition, NNIs tend to accumulate in the food chain, leading to potential adverse effects on human brain development.

In recent decades, the European Union (EU) has strengthened policy frameworks to prevent biodiversity loss and transform food systems, most recently with the launch of the EU Biodiversity Strategy for 2030 and EU Farm to Fork. Adoption of many biodiversity-friendly practices, such as organic farming (+50% over 2012-2020 according to the Directorate-General for Agriculture and Rural Development (2023)), and regulatory measures have increased. In 2013, the **EU** banned the use of **three NNIs (clothianidin, imidacloprid and thiamethoxam)** on crops attractive to bees, including sunflowers, oilseed rape and maize (corn) for two years, pending further study of their safety.

1.1.2.2 French context

France's institutional changes stand out as unique compared to those of its European neighbors. France banned the use of imidacloprid on sunflowers in 1999 and on corn in 2004. Later, as part of the parliamentary debates surrounding the **"Law for the Reconquest of Biodiversity, Nature and Landscapes"** (Law No. 2016-1087), the French Minister of Agriculture tasked ANSES with assessing the risks and benefits of alternative plant protection products or non-chemical prevention/control methods for neonicotinoid containing products in France (Ballot et al., 2018). Subsequently, Article 125 of the law **banned** the use of the **five main neonicotinoids** that are harmful to pollinators and human health from September 1, 2018, with possible exemptions until July 1, 2020, subject to a benefit and risk assessment. Despite opposition from farmers' unions and pesticide manufacturers arguing for the necessity of these pesticides in crop

[9] see Blacquière et al. (2012), EFSA (2012), Henry et al. (2012), Nicholls et al. (2018), Whitehorn et al. (2012)

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protection, there is evidence linking neonicotinoids to declining bee populations (Bomgardner, 2013, Butler, 2018). France also banned by decree (Decree No. 2019-1519 of December 30, 2019) the two other active ingredients in plant protection products that have the same mode of action as the neonicotinoid family: sulfoxaflor and flupyradifurone.[10]

Due to a widespread outbreak of mild yellow virus transmitted by the green peach aphid, *Myzys persicae* (Hemiptera: Aphididae) in 2020, France implemented specific exemptions in 2021 and 2022 to allow the use of neonicotinoids on certain crops, including beets. At that time, the French sugar beet industry faced a severe crisis, resulting in yield losses and reduced sugar production (Laurent et al., 2023, Verheggen et al., 2022). However, these exemptions were repealed by the Conseil d'Etat on November 2022.[11]

1.1.2.3 Mechanisms of the instrument for internalization

Figure 1.2 illustrates the pathways of effects from the implementation of a ban on NNIs tax to changes on health, social and environmental externalities.

[10] Sulfoxaflor is a systemic insecticide that acts as a neurotoxin. It has been presented as the ”most likely successor” to neonicotinoids. Flupyradifurone, commercially known as Sivanto, is an organochlorine compound that functions as a systemic insecticide belonging to the neonicotinoid class and classified within the butenolide group. It exhibits neurotoxic properties and shares structural similarities with imidacloprid.

[11] The mild yellow virus was controlled using neonicotinoid-treated seeds, with clothianidin and thiamethoxam present in almost all conventionally cultivated sugar beet fields (Hauer et al., 2017, Verheggen et al., 2022). To safeguard French food and energy sovereignty and protect the 46,000 jobs in the sector, Law 2020-1578 was implemented. It allowed for exceptional derogations from the prohibition laid down in Article L. 253-8 of the Code of Rural and Maritime Fisheries. These derogations allowed the use of sugar beet seed treated with pesticides containing imidacloprid or thiamethoxam, initially authorized by the decree of February 5, 2021, with an additional one-year derogation granted by the decree of January 31, 2022.

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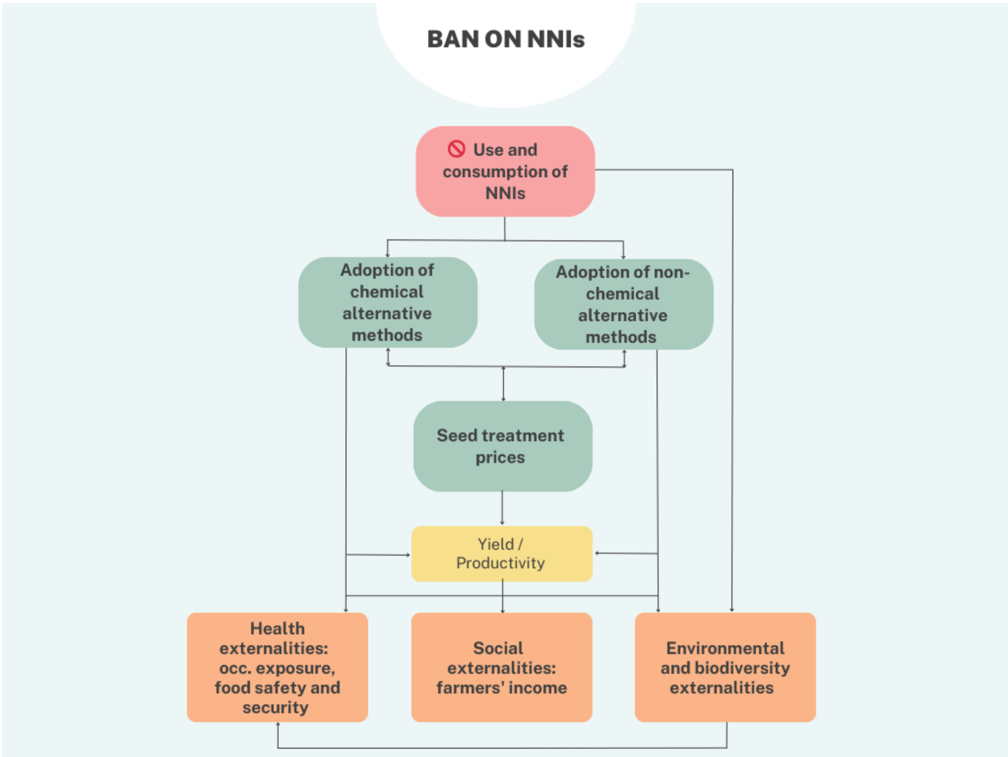

Figure 1.2: Pathways of Effects

1.1.2.3.1 Impact on production costs

Pesticide bans are becoming increasingly common as governments around the world take steps to protect human health and the environment. While these bans are often necessary, they can have a significant impact on farmers and growers. Although the findings are based on a limited number of studies, they provide valuable insights that may be applicable to the case of France and Europe, depending on the local context. The neonicotinoid ban in France may have represented a paradigm shift in agricultural production with a significant impact on production costs. The impact on production costs depends on the effect on **yields**, the **availability of alternative methods** and the **price of seed treatments**.

1.1.2.3.1.1 Impact on yields

Neonicotinoids are extensively used in agriculture with the intention of enhancing crop yields (Jeschke et al., 2011). This has given rise to a discourse regarding the prohibition of these pesticides, a measure that could have direct and multifaceted implications for crop yields, profitability, shifts in pest management strategies, and market dynamics (Bonmatin et al., 2015)

In the United States, studies in a variety of agricultural contexts show that neonicotinoids either do not provide yield benefits[12] or do so inconsistently[13] under moderate to low pest pressure according to the review of Stevens and Jenkins (2014). This calls into question the economic justification for their prophylactic use (APENET, 2010, Mole et al., 2013, Stokstad, 2013a). Despite their widespread use, it is striking that there is a lack of field research demonstrating the efficacy of neonicotinoids in increasing yield (Budge et al., 2015). Interestingly, some recent studies have revealed evidence of potential yield reduction, prompting questions about their true value to growers (Douglas and Tooker, 2015). This finding may be explained by the fact that the targeted pests are not always present or cause non-significant damage. However, in cases where these pests do manifest, it becomes imperative for growers to have effective management strategies at their disposal (APENET, 2010, Simon-Delso, 2014).

Summary report from France, the United Kingdom and Italy collectively show that neonicotinoids provide little or negligible economic benefit in many contexts. Unlike their North American counterparts, these analyses provide detailed before and after case studies, as these countries have imposed restrictions on neonicotinoid use in a variety of crops (Budge et al., 2015, Simon-Delso, 2014, Stokstad, 2013b). For instance, after the ban on imidacloprid on sunflowers in 1999 and on corn in 2004 in France, the yield trends for both crops through 2007 show that the productivity was not harmed by the loss of seed treatment as a pest control measure (Stokstad, 2013a).

In conclusion, although there is no empirical evidence of a causal effect of the neonicotinoid ban on yields, it is worth considering this issue in the context of the French beet industry.

Nevertheless, the economic impacts of a neonicotinoid ban are complex and likely to vary by region and crop type, requiring more context-specific analyses (Bonmatin, 2017, Simon-Delso, 2014). The magnitude of the impact depends heavily on factors such as the type of crop, the prevalence and nature of the pests, and the availability and effectiveness of alternative pest management strategies. For example, crops that have traditionally relied heavily on neonicotinoids for pest control, such as sugar beets, may experience greater yield losses and cost increases than crops for which effective alternative pesticides or biological control methods exist (Douglas et al., 2015). Interestingly, a study focused on oilseed rape finds that neonicotinoid seed coatings resulted in increased yields (Budge et al., 2015).

1.1.2.3.1.2 Substitution of plant protection products and their effects

The scientific literature on the impact of a neonicotinoid ban and the associated **substitution possibilities** is diverse. Several studies, especially in biology and ecology, discuss the possibility of substituting neonicotinoids with other **chemical** or **non-**

[12] see e.g. Cox et al. (2007, 2008), Petzold-Maxwell et al. (2013), Reisig et al. (2012), Seagraves and Lundgren (2012), Tinsley et al. (2012), Wilde et al. (2019)

[13] see e.g. Cox and Cherney (2011), Esker and Conley (2012), Johnson et al. (2009), Jordan et al. (2012), Magalhaes et al. (2009), McCornack and Ragsdale (2006), Ohnesorg et al. (2009), Pynenburg et al. (2011), Royer et al. (2005), Soroka et al. (2008), Wilde et al. (2007)

chemical alternatives (Budge et al., 2015, Douglas and Tooker, 2015, Furlan and Kreutzweiser, 2015). Since NNIs are cost-effective bundling, they offer a favored solution for farmers to preemptively handle various pest issues, resulting in widespread usage and difficulty finding untreated seeds.

The effectiveness of these **chemical alternatives** and their impact on yields and farm profitability has also been widely debated (Budge et al., 2015). The ban could fuel dependency on other insecticide classes (Furlan and Kreutzweiser, 2015). While chemical alternatives such as pyrethroids, organophosphates, and carbamates are commonly mentioned, they may be less effective and potentially more harmful to non-target organisms (Stokstad, 2013a). This can also incur **high switching costs**, as they may need to purchase new equipment or staff training on how to use new products. The urgency following a pesticide ban could exacerbate these burdens, as farmers rush to find new pesticides while dealing with unmarketable produce and outdated pesticide stocks.

Non-chemical methods, such as biocontrol measures, crop rotation, and the use of pest-resistant crop varieties, are also promising but may not provide the same level of pest control efficiency (Furlan and Kreutzweiser, 2015). Moreover, while these alternative strategies can help control pest populations, they might require significant farm management transformations, bearing varying **higher costs** and impacts on crop yield (Altieri, 2000). Biological pest control, while environmentally benign and potentially effective, depends on specific conditions for success and can be more costly and complicated to manage (Bale et al., 2008). The ban might also incite farmers to switch to crops less at risk to pest growth if alternative pest control methods prove less effective than neonicotinoids (Godfray et al., 2015). Additionally, this could spur the adoption of precision agriculture technologies, like drone monitoring and targeted pesticide application (Zhang, 2016).

1.1.2.3.1.3 Impact on seed treatment prices

Existing literature provides insights into the potential consequences of a neonicotinoid ban on seed treatment prices, although no study has directly quantified this impact. They explore seed market dynamics, crop productivity, and the potential increase in seed treatment costs due to the requirement for more costly substitutes (Ionel, 2014, Simon-Delso, 2014).

The neonicotinoid ban could alter seed treatment practices and associated costs. The switch to more expensive substitutes could potentially elevate seed treatment costs. The market’s response to these changes is uncertain, given it is influenced by price, application complexity, and pest control effectiveness. These variables could change the cost of treated seeds and thus the production costs for farmers (Breeze et al., 2014). An uptick in demand for non-neonicotinoid seed treatments could temporarily inflate prices due to a supply-demand imbalance. As suppliers adjust their product offerings to match new demand trends, prices might stabilize over time. If more affordable or similarly priced alternatives are less effective, this might lead to a surge in total pest management costs due to the requirement for supplementary measures (Furlan and Kreutzweiser, 2015). This could indirectly influence the overall seed treatment costs. The work of Bonmatin et al. (2015) investigates the hidden and external costs of pesticides, including neonicotinoids. The authors underline that the elevated costs of alternative seed treatments could be balanced out by the reduction in environmental and health impacts linked to neonicotinoid use.

1.1.2.3.2 Potential limitation of the ban policy in the case of pest resistance

The ban on neonicotinoids in France is a complex issue that encompasses broader ecological considerations (Goulson, 2013) and the challenge of maintaining sustainable agricultural practices. Pesticides like neonicotinoids are typically used as integrated pest management tools to control pests and diseases that threaten crops' health and productivity (Bale et al., 2008). However, the ban could lead to new challenges, including the potential increase in pest resistance (Bass et al., 2015, Romero and Anderson, 2016). Lundin (2021) report an increase in stem flea beetle populations in oilseed rape production after a neonicotinoid ban. This resulted in higher costs over time as pests developed resistance to other pesticide families in the sector (Scott and Bilsborrow, 2019).

The evolution of pest resistance can especially escalate under mono-culture conditions where pests are exposed to the same pesticides over a prolonged period. This provides pests a selective advantage and an opportunity to adapt, potentially leading to the unintentional development of super-pests that are resistant to many available pesticides. Furthermore, the concern about cross-resistance, where resistance to one chemical can confer resistance to others—even if the pest has not been previously exposed to the latter—increases with the introduction of a neonicotinoid ban (Scott et al., 2015). Consequently, dependence on a narrowed range of insecticides after the ban may heighten the risk of cross-resistance.

1.1.2.3.3 Impact on consumer prices

The neonicotinoid ban in France and Europe presents several challenges that are expected to impact the agricultural sector and, more broadly, consumer prices. The ban could result in increased production costs due to the potential need to switch to alternative pest control methods and reduced yields due to the lower efficacy of these alternatives. These effects could subsequently drive-up agricultural commodity prices (Bonmatin et al., 2015). However, to date, there is no evidence on the causal impact evaluation of such policy on consumer price changes.

1.1.2.4 Policy impacts on externalities

The policy impact on externalities will depend on the type of substitution that farmers choose in response to the ban, either chemical or non-chemical alternatives.

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Apart from limited case study evidence following the EU and French neonicotinoid bans, there are no large-scale studies documenting the effects of widespread neonicotinoid use and bans. Most estimates of impacts come from correlations between outcomes (e.g. biodiversity, environment, public health) and neonicotinoid exposure or bans, which may be biased by unobserved factors such as climate, soil quality, plot size and crop type. Another limitation is that these estimates are often based on experimental plots, which do not provide evidence of results under realistic field conditions.

1.1.2.4.1 Impacts on environmental and biodiversity externalities

While the neonicotinoid ban has potentially significant benefits for the environment and biodiversity conservation, a comprehensive perspective is needed, considering potential trade-offs and synergies. Long-term environmental impacts will depend on how pest management strategies adapt to the ban (Lechenet et al., 2017).

In response to the policy ban on neonicotinoids, the adoption of integrated pest management, crop diversification, and organic farming practices could provide additional environmental and biodiversity benefits (Lechenet et al., 2017). Indeed, by removing these harmful chemicals, the ban may promote more robust ecosystems and sustainable agriculture (Bonmatin, 2017).

While effective against targeted pests, neonicotinoids are also harmful to non-target terrestrial species, including pollinators such as honeybees (Henry et al., 2012; Whitehorn et al., 2012; Woodcock et al., 2017; Lundin, 2021). However, other gaps in the evidence base that has been presented in support of the moratorium are also striking. While most studies focus on *Apis* species, few examine other pollinators such as wild bees as important providers of ecosystem services (Blacquière et al., 2012; Godfray et al., 2014) or non-target invertebrates and vertebrates, including birds (Li et al., 2020), especially grassland and insectivorous species (Gibbons et al., 2014; Pisa et al., 2015).[14] In addition, the ban could reduce soil and water contamination given the high persistence and systemic nature of neonicotinoids (Botias et al., 2015; Bonmatin et al., 2015). These toxins threaten non-target organisms vital to soil fertility and aquatic food chains, such as earthworms and aquatic invertebrates (Pisa et al., 2015; Goulson, 2013). As a result, by reducing the prevalence of neonicotinoids in the environment, the ban could help restore food web dynamics disrupted by these pesticides, thereby increasing ecosystem resilience (Chagnon et al., 2015).

It is critical to note, however, that these benefits could be jeopardized if substitute pesticides with their own detrimental impacts are introduced (Kathage et al., 2018; Bass and Field, 2018). There is growing evidence that even low, persistent concentrations of these insecticides pose serious environmental risks, calling into question the sustainability of current reliance on these compounds (Tennekes and Sanchez-Bayo,

[14] However, there is some debate in the literature about the link between recent pollinator declines and neonicotinoids, with research suggesting that the declines are not necessarily caused by neonicotinoids due to non-temporal coincidences (Blacquière et al., 2012). Also, the short time frame makes it difficult to assess the impact of the French ban.

2011; Roessink et al., 2013; Furlan and Kreutzweiser, 2015). Therefore, if farmers replace neonicotinoids with other harmful pesticides, the net gain for biodiversity may be minimal (Geiger et al., 2010). Factors such as agricultural intensification, which reduces the diversity of food crops on which insects depend (Barr et al., 1993) and increases exposure to multiple pesticides with potentially synergistic insecticidal effects (Bingham et al., 2008), must also be considered.

1.1.2.4.2 Impacts on social and health externalities

While the primary concerns about neonicotinoids have been environmental, there are also potential impacts on human health. Unfortunately, the literature on the effects of a neonicotinoid ban is less extensive than that on the environmental effects, as the human health effects are indirect and typically linked to changes in biodiversity and agricultural practices.

1.1.2.4.2.1 Social externalities

1.1.2.4.2.1.1 Food security

The neonicotinoid ban in France poses several challenges that are expected to affect food security in different ways.

On one hand, the ban on neonicotinoids could potentially enhance long-term food security by encouraging biodiversity and sustainable agricultural practices such as IPM (Furlan and Kreutzweiser, 2015; Lechenet et al., 2017). Shifting away from neonicotinoids could help reduce environmental damage and improve pollinator health, which is critical to future food supply as the world's population grows (Matson et al., 1997; Klein et al., 2007; Potts et al., 2010; Botias et al., 2015).

On the other hand, if the absence of neonicotinoids negatively impacts crop yields — an effect yet to be definitively proven — there could potentially be long-term adverse implications for food security (Godfray et al., 2010).

1.1.2.4.2.1.2 Impact on farmers' income (fair wage)

The potential financial impact of a neonicotinoid ban, particularly in the short term, can be significant, affecting overall farm profitability whenever it generates potential yield losses from changes in pesticide use. However, research provides a more nuanced view of these impacts, suggesting that while the initial impact may be negative, there may be long-term economic offsets and environmental benefits (Whittaker, 1995; Ørum et al., 2002; Jacquet et al., 2010; Budge et al., 2015).

Budge et al. (2015) highlight that while there may be initial income losses due to yield reductions, these losses could potentially be offset over time by healthier pollinator populations and more stable ecosystems. Thus, a reduction in pesticide use does not necessarily lead to a reduction in farmer income. Similarly, Ørum et al. (2002) report that a substantial reduction in current levels of pesticide use wouldn't necessarily have severe economic consequences. Jacquet et al. (2010) go further, suggesting that a 30% reduction in pesticide use could be achieved without affecting farmers' incomes.

1.1.2.4.2.2 Health externalities

1.1.2.4.2.2.1 Food safety

The potential impacts of a neonicotinoid ban are numerous and complex on food safety. These impacts are mainly derived from pesticide residues in food products, both directly from the removal of neonicotinoids and indirectly, depending on the substitutions chosen by farmers in response to the ban (whether they choose for different insecticides or adopt more environmentally friendly practices).

In terms of direct impacts, the ban could affect the prevalence of pests in food crops, as NNIs are often used as a preventative measure in seed treatments (Goulson, 2013). The ban could be directly beneficial for food safety as the NNIs penetrate the plant, including consumable parts (Simon-Delso, 2014; Chagnon et al., 2015). Several studies highlight their presence in fruits, vegetables, and honey commonly consumed by humans (Chen et al., 2014; Zhang et al., 2019). Zhao et al. (2020) reviews the potential toxicity and human health effects of NNIs and concludes that long-term exposure may pose risks to both animals and humans. Thompson et al. (2020) further show the environmental fate and toxicity of neonicotinoids and their metabolites, finding them to be ubiquitous in the environment, drinking water, and food, with common low-level exposures below acceptable daily intake standards. Although neonicotinoids are generally considered less directly toxic to humans than older classes of pesticides, ongoing research into their potential health effects suggests possible links to adverse developmental or neurological outcomes (Cimino et al., 2017; Douglas and Tooker, 2015). In addition, the high solubility of neonicotinoids facilitates their leaching into water bodies, potentially contaminating drinking water sources. This contamination could be mitigated by a ban, further benefiting human health (Morrissey et al., 2015; Botias et al., 2015).

However, the removal of this protection could result in increased pest resistance, leading to potential food safety issues in terms of pesticide residues if alternative pesticides prove to be less effective or require larger quantities (Bass and Field, 2018). Increase use of other, potentially more harmful pesticides following a ban on neonicotinoids could negatively affect public health. Some alternatives may be indeed more hazardous, exhibit higher levels of toxicity, and may leave larger residues in food (Bonmatin et al., 2015). For example, organophosphates, an older category of insecticides often replaced by neonicotinoids, are particularly toxic to humans and other mammals (Bonmatin et al., 2015; Mostafalou and Abdollahi, 2017).

1.1.2.4.2.2.2 Occupational and residential exposure

The neonicotinoid ban in France has potentially significant impacts on occupational exposure, particularly for agricultural workers and individuals involved in pesticide production and application. Although no studies explicitly discuss these effects, it is plausible to infer that the ban would significantly reduce exposure to these chemicals (Cimino et al., 2017; Seltenrich, 2017). Neonicotinoids, which are widely used in agriculture, have been linked to both acute and chronic health problems, including respiratory, cardiovascular, and neurological symptoms, oxidative genetic damage, and birth defects (Thompson et al., 2020). The broader health effects of pesticide exposure also include neurodegenerative diseases such as Parkinson's and Alzheimer's and cognitive function, pregnancy complications, potential fertility problems (Strobl et al., 2021; Hoshi et al., 2014; Gu et al., 2013), and certain types of cancer (Cimino et al., 2017; Bellinger, 2012).

Moreover, the impact of the ban could vary depending on whether farmers choose to switch to more environmentally friendly alternatives or substitute other chemicals. If farmers switch to more environmentally friendly practices, occupational exposure to harmful pesticides would likely decrease. In contrast, substituting other chemicals could expose workers to a different set of health risks. Therefore, the impact of the ban on occupational exposure will depend on the choices farmers make in response to the ban.

1.2 Biotechnology: Genetically Modified Organisms

Key findings

- Modern biotechnology, including genetically modified crops (GM), has seen considerable advancements, with applications addressing agricultural challenges and offering potential for food security. Despite the potential benefits, concerns about environmental impact, biodiversity loss, and food safety have been raised.

- The only GM maize approved for cultivation in the EU is MON810, which is mainly grown in Spain and Portugal. In France, the cultivation of transgenic maize is marginal, accounting for only 0.08% of the total utilized agricultural area in 2017. The regulation of GM crops varies across countries; within the EU, Member States have autonomy to decide whether to allow GMO cultivation. For instance, France has implemented a *moratorium* followed by a ban on GM crop cultivation due to societal concerns.

- The ban on MON810 genetically modified corn in France could have mixed effects, including potentially higher production costs, lower yields, and reduced profitability, but these effects could be offset by higher market prices for non-GM crops due to consumers' willingness to pay a premium for such products.

- A ban on the GMO MON810 could reduce genetic pollution and biodiversity loss, but could also increase pesticide use, adversely affect soil ecosystems, and potentially escalate greenhouse gas emissions due to land-use changes and increased demand for fertilizers and pesticides. It also has complex implications for public health, particularly through increased exposure to pesticides, and could alter economic opportunity costs and innovation in biotechnology.

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1.2.1 Introduction

Modern biotechnology is derived from ancient agricultural practices that involved the creation of nonnatural plants through cross-species breeding (Dunn et al., 2017). The modern methods for plant genetic engineering were established in the 1980s, and the first commercially available genetically modified (GM) crops appeared in 1996. Advances in biotechnology have led to novel genomic technologies (NGTs),[15] which facilitate the development of new plant varieties through the manipulation of genetic material (DNA) or the targeted integration of specific genes[16] into organisms. GM crops are primarily designed to address agricultural challenges. Food biotechnology has been seen as a potential opportunity to tackle food security and safety as the population continues to grow and the EU agricultural lands continue to shrink (Perpina Castillo et al., 2018). The most common genetic modifications in crops involve the expression of insect-resistant or herbicide-tolerant proteins. An example is the expression of crystal proteins[17] produced by *Bacillus thuringiensis (Bt)*, a bacterium that has existed naturally in the environment for more than 50 years and is used as a biological insecticide against disease-carrying insects such as mosquitoes (Hammond and Koch, 2012), European corn borers, and noctuid moths.

Since their introduction to the market in 1996, GM crops are steadily increasing worldwide (European Commission, 2023). By 2014, more than 18 million farmers from 28 countries grew GM crops, covering about 4 billion hectares (Dunn et al., 2017). A total of 29 countries, including USA, Brazil, Argentina, Canada, and India, planted biotech crops in 2019 (James et al., 2019).

In the European Union (EU), Member states have the discretion to allow or prohibit the cultivation of GM crops on their territory. About 100 GMOs in food and feed have been approved in both the EU and France, including maize, soybean, rapeseed, cotton, and sugar beet (ANSES, 2023). However, only one GM corn variety, MON810, was approved for cultivation, with 96% of the crop being located in Spain and the remaining in Portugal. Monsanto has developed insect-protected corn even MON810 by inserting cry1Ab gene which naturally produces *Bt* protein in the maize.

The regulation of GM foods and crops varies from country to country in the EU, and some countries have banned the cultivation of MON810, including France. France distinguishes itself from other European countries by engaging in a prolonged and intense mistrust surrounding GMOs and implementing a *de facto moratorium* as part of the *Grenelle de l'Environnement* initiative (September-December 2007). The moratorium has been justified by possible societal implications of biotechnology.

[15] Under the EU's Food Law, the term NGTs is used to refer to technologies that have been developed over the past two decades after adoption of Directive 2001/18/EC on the deliberate release into the environment of GMOs (see Section 1.2).

[16] Genes are defined as distinct segments of DNA responsible for encoding proteins.

[17] Inserting a gene into the food plant enables the production of a toxin from the bacterium.

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While concerns have been raised on GMO in France and other European countries, GMOs are also recognized for their potential to promote sustainable agriculture through increased crop yields (first generations), food quality (second-generation GMOs) reduced pesticide use, lower CO_2 emissions, and soil and moisture conservation (OECD, 2000; James, 2011; Christou et al., 2013).[18] Despite their potential benefits, concerns remain about the potential long-term environmental, biodiversity loss, and food safety impacts of GM crops, particularly toxicity and food allergies (Christou et al., 2013). Traditional toxicological approaches assess potential risks, with initial claims of intestinal mucosal damage in rats fed GM potatoes (Ewen and Pusztai, 1999) being refuted by subsequent research (Burke, 2004; Key et al., 2008). Besides, research results have consistently found no adverse health effects in animals fed with GM maize (Bartholomaeus et al., 2013; Domingo, 2016; Snell et al., 2012; Coumoul et al., 2018). Food allergies are also a major point of controversy in the GMO debate in Europe (Madsen, 1997)[19], but there is currently no robust evidence to suggest a causal link with GMOs (Xu, 2015; Howell et al., 2018).[20]

1.2.2 EU Policy Framework

The European Commission is proactively monitoring advances in modern biotechnology to assess how the EU can appropriately harness innovation in the food and agriculture sector, in line with the objectives set out in the European *Green Deal* and the *Farm-to-Fork Strategy*. Within this framework, EU legislation on GMOs has two main objectives: to safeguard human and animal health and the environment in accordance with the precautionary principle, and to ensure the effective functioning of the internal market.

To regulate the deliberate release of GMOs into the environment, **Directive 2001/18/EC** establishes standardized and centralized procedures requiring authorization by the competent authorities before a GMO can be placed on the market (either as a single entity or as part of a product) or deliberately released into the environment. It is important to note that this Directive and its subsequent applications do not cover GMOs resulting from specific genetic modification techniques/methods (such as mutagenesis and cell fusion of plant cells from certain organisms), which are subject to specific conditions. However, under **Regulation (EC) No 1829/2003 relative to genetically**

[18] Genetic engineering can also potentially contribute to the modification of laboratory animals and the use of diverse animal species, possibly even the reintroduction of extinct species (European Commission, 2021). GM crops, such as corn borer resistant corn, can also reduce exposure to mycotoxins, improving quality and crop and potentially consumer health.

[19] Recent trends indicate an increase in the incidence of these allergies (Lyons et al., 2020; Spolidoro et al., 2023), affecting an estimated 20 million people, including a quarter of all school-aged children. Food allergies have a significant impact at both the individual and macroeconomic levels. Those affected by allergies experience reduced quality of life and incur additional financial and social burdens, such as reduced access to education and impaired child development (EAACI, 2021). While transgenesis itself does not cause allergies, the introduction of new proteins or products, including GMOs, may trigger reactions in some individuals (Poulsen, 2004; Anderson et al., 2006).

[20] Despite studies highlighting the unpredictability and potential hazards of GM technology (Nordlee et al., 1996; Prescott et al., 2005), safety testing is believed to address these issues before product release (Madsen, 1997). Some link the rise in soy allergy cases in the UK to the development of GM soy in the US (Herman, 2003), but there is no substantial evidence to support a causal link between GMOs and food allergies (Xu, 2015; Howell et al., 2018).

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modified food and feed, the European Commission gives Member States the autonomy to decide whether to allow the cultivation of GMOs on their territory. This approach recognizes consumer concerns about GMOs and the unique characteristics of each Member State at the local, regional, and national levels. In addition to strict regulations, the EU has imposed restrictions on several transgenic crops. Of these, MON810 is the only *Bt* corn variety approved for cultivation in the EU.

1.2.3 Ban on MON810 in France

1.2.3.1 Introduction

France was the first country, along with Spain, to cultivate GMOs in 1998 (Schreiber, 2020), but also one of the first to activate the safeguard clause to ban them. The country cultivated three transgenic maize varieties (MON810, Bt176 and T25), which were approved by the French Ministry of Agriculture in February 1998. Bt176 was withdrawn from the market by Novartis (now Syngenta), while T25 was never cultivated. The cultivation of transgenic maize was marginal with only 1,965 ha (0.006% of total UUA in France) in 1998. It remained insignificant until 2007, when declared areas peaked at 22,135.25 hectares (0.077%), concentrated mainly in the southwest of France. Following new scientific evidence of environmental risks (resistance in certain insects, impact on flora and fauna), the government decided in 2008 to suspend the cultivation of MON810 maize in France, applying the precautionary principle and the safeguard clause provided for in European legislation (Directive 2001/18/EC and Regulation 1829/2003). This moratorium was challenged by the seed industry before being overturned by the Conseil d'État in 2011. The government adopted two new moratoria in 2012 (annulled in 2013 by the Conseil d'État for non-compliance with EU law) and 2014 (annulled in 2016). In 2015, the French government decides to maintain the MON810 ban, using the "opt-out" provision just agreed upon by the 28 EU member states. Despite this policy ban, the import and marketing of genetically modified food or feed are permitted in France, as long as these products have been previously authorized at European level and must be labeled in accordance with European regulations (see EU regulations on labeling and traceability). Appendix A1 details the regulatory framework and timeline regarding GMOs in France.

Other EU countries have also banned GMOs, including Germany, Austria, Greece, Hungary, the Netherlands, Latvia, Lithuania, Luxembourg, Bulgaria, Poland, Denmark, Malta, Slovenia, Italy, and Croatia.[21]

1.2.3.2 Mechanisms of the instrument for internalization

[21] Other countries in the world have also banned GMO. In Africa, Algeria and Madagascar have enacted GMO bans. In Asia, Turkey, Kyrgyzstan, Bhutan, and Saudi Arabia have implemented similar measures. In the Americas, Belize, Ecuador, Peru, and Venezuela have also banned GMOs.

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Figure 1.3 illustrates the pathways of effects from the implementation of a ban on GMOs tax to changes on health, social and environmental externalities. In this section, we describe the main mechanisms triggered by the GMO ban. We present its potential impact on production costs, including profitability and yields, seed treatment prices, and profit margins. We also discuss other cost saving opportunities. Finally, we describe the impact of the MON810 ban on final prices.

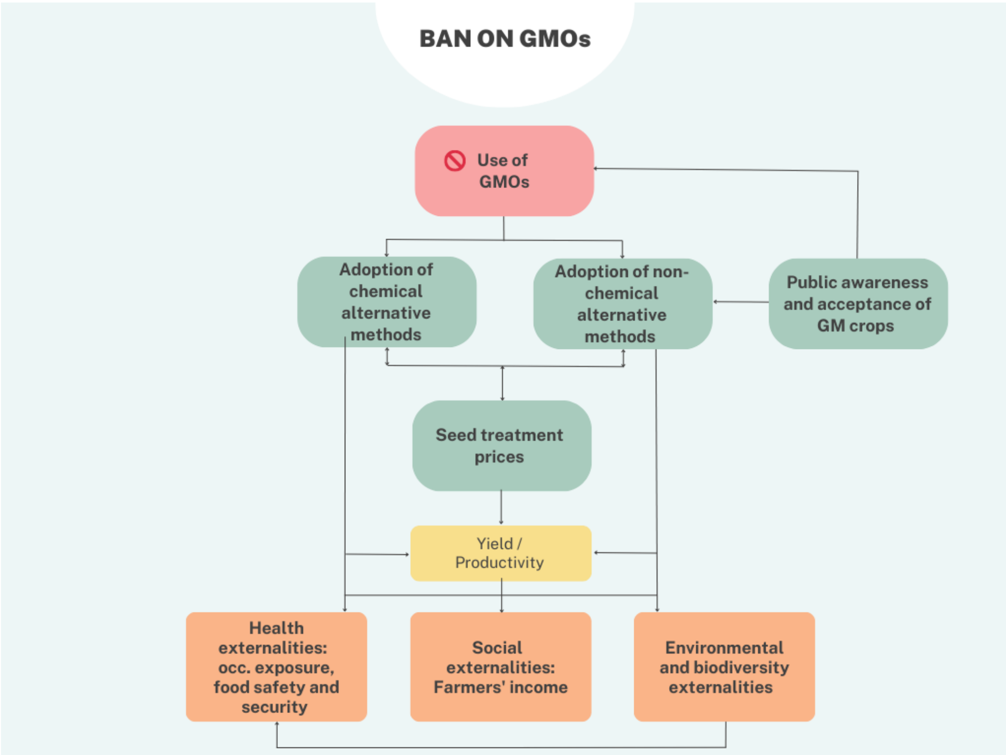

Figure 1.3: Pathways of Effects

1.2.3.2.1 Effect on production costs

While the impact of the ban on production costs and yields in the French context remains uncertain, observed global trends suggest mixed results in terms of profitability and yields, seed treatment prices, and cost savings from coexistence measures.

1.2.3.2.1.1 Effect on seed treatment prices

The ban on MON810 in France has a marginal impact on the agricultural industry, particularly on **seed treatment prices**. The regulation requires a return to conventional seed treatments, with potential **cost implications**. The loss of MON810's inherent pest resistance could increase reliance on conventional pesticides. Increased seed treatment demand for other pesticides could drive up their prices and increase the overall production costs. In addition, farmers may need to invest more in crop health monitoring and pest management, increasing further costs (Venus et al., 2011).

However, these potential price increases need to be viewed in a broader context. While the cost of seed treatments may increase, this may be offset by premium pricing opportunities for non-GM products in the market.

1.2.3.2.1.2 Effect on profitability and yields

The MON810 corn ban has generated considerable discussion about its potential impact on farm profitability and yields. MON810 is designed to resist certain pests that can devastate crops and significantly reduce yields. Prior to the ban, farmers using MON810 had the potential to increase **profitability** by reducing the need for chemical pesticides (Raman, 2017; Oliver, 2014) and improve crop production efficiency (Buiatti et al., 2013). However, the ban has required a reevaluation of crop management strategies, potentially leading to increased uncertainty and expenditures on alternative pest control methods (Mahaffey et al., 2016; Nielsen and Anderson, 2000) and decreased profits due to reduced yields (Azadi et al., 2016). In a broader context, a ban could counteract average yield increase associated with the adoption of GM technologies. For instance, the meta-analysis in Klümper and Qaim (2014)'s finds that the average yield increase can reach 22% but could not be achieved with a ban worlwide. Similarly, Betbesé and Lucas (2007) estimate a 7.5% yield gain from MON810 maize in Catalonia, Spain. The impact on profitability of the ban would also depend on the effectiveness and cost of alternative pest control strategies, as well as the ability of farmers to adapt their practices to non-GMO cultivation. Moreover, because GM crops optimize land use and reduce costs (Lucht, 2015), such a ban could increase land costs. Because conventional seeds may not produce the same yield as the GMO variety, they can result in lost revenue. The impact on yield, combined with increased operating costs, poses a challenge to maintaining profitable farming operations. For example, the break-even point for *Bt* maize adoption found in Venus et al. (2011) suggests a required yield increase of 1.5% in Spain, 2.8% in Italy, and 3.3% in Germany.

In short, the impact on profitability is closely linked to crop yield. A significant reduction in yields can lead to lower profits unless offset by higher crop prices. However, if non-GM crops can command higher market prices, this can mitigate losses due to lower yields.

1.2.3.2.1.3 Effect on profit margins

Studies have shown that profit margins for GM crops vary between 240 to 400€ per hectare and exceed those for conventional crops (90 to 140€), depending on location and time (Bourguet et al., 2009; Venus et al., 2011). Thus, if GMOs were banned, margins could potentially shrink, with the gross margin advantage of GM maize over non-GM maize estimated to fall to 43€/ha (Messean et al., 2006), while Venus et al. (2011) estimate that the highest average gross margin surplus occurred in Spain (185 €/ha), followed by Italy (132 €/ha) and Germany (66 €/ha).

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However, it should be noted that in the longer term, the impact of the MON810 ban on farm profitability may depend on several factors, including the volatility of seed treatment prices and the development and effectiveness of alternative pest management strategies (Venus et al., 2011; Nawaz et al., 2020), and the premiums that can be achieved in the market for non-GM crops. It remains critical for policymakers to carefully monitor these dynamics to ensure the sustainability and economic viability of French agriculture.

1.2.3.2.1.4 Indirect effects from co-existence measures

The potential ban on MON810 could also have an impact on the cost savings associated with the coexistence measures required by the French law on GMOs (Law No. 2008-595 of June 25, 2008). These measures, which aim to mitigate potential risks, establish reporting requirements, ensure the implementation of coexistence strategies, and provide financial guarantees to non-GMO farmers. If the GMO ban were to be lifted, this would significantly reshape the arable landscape, potentially leading to increased costs and efforts for farmers (Bourguet et al., 2009; Venus et al., 2011). In addition, under a GMO ban, farmers may find it easier to market their harvests, as they would no longer need to check whether storage facilities accept GMOs. The need for dedicated storage for GM and non-GM products and possible specialization of equipment to prevent the accidental presence of GMOs would be eliminated, reducing both concerns and costs (Bourguet et al., 2009).

1.2.3.2.2 Impact on final prices

1.2.3.2.2.1 Direct market impact on prices

The ban on MON810 in France might have an impact on the final market prices of agricultural products, but little quantitative work has been done on the extent to which the cost shocks are transmitted along the food chain in Europe. Because of the shift back to conventional crops, the ban may affect the market prices of seeds, pest control, crop yields, and ultimately the final market price of agricultural products. Indeed, these increased production costs could directly affect the final market prices, resulting in more expensive agricultural products. In addition, the potential reduction in crop yields due to the absence of MON810's pest resistance trait could further tighten supply and drive-up prices.

While there is a lack of literature on the subject in France, there are some assessments in other non-EU countries. First, the 2022 report by World Perspectives, Inc. & Arlington, VA (2022) predicts significant cost impacts due to a potential GM corn ban in Mexico[22], resulting in a 19% increase in corn costs over a decade, leading to more expensive food and consumer products for Mexicans. Second, the study by Mahaffey et al. (2016) assesses the global economic (and greenhouse gas emissions) impacts of GM crop banning scenarios. They assess two counterfactual scenarios separately and in combination. The first scenario models the impact of a global GMO ban, while the second scenario models the impact of increased GMO adoption. Overall, the authors find that at the global level, food prices are only marginally affected, with an increase of only 0.8%. A 0.8% price increase still amounts to about $44.83 billion, ceteris paribus (i.e., assuming consumption levels remain fixed), resulting in a global welfare loss of $7.78 billion. Notably, EU food prices are also relatively unaffected.

1.2.3.2.2.2 Indirect impact from public awareness and acceptance

These direct economic impacts are nuanced by the market dynamics surrounding GMOs and non-GMOs. The ban and more stringent GMO regulations in Europe have shaped consumer preferences (Mahaffey et al., 2016), with a significant proportion of European consumers willing to pay a premium for non-GMO products outside France (Carlsson et al., 2004; Costa-Font et al., 2008). This perception of consumers on GMO is particularly strong in France, where the introduction of GMOs has raised public awareness and fear, increased skepticism, institutional distrust (Bonny, 2003; Costa-Font and Mossialos, 2005) and consumer aversion. Consumers prefer non-GM products (Mahaffey et al., 2016), perceive minimal benefits from GM products (Marris, 2001; Wynne et al., 2001; CAE, 2003), have safety concerns (Chiang et al., 2005), and worry about the consequences of genetic modification (Christou et al., 2013; Marris, 2001).

Therefore, even if final market prices increase due to higher production costs, farmers may still benefit because these costs may be partially or fully offset by the fact that consumers are willing to pay a premium for non-GM products.

1.2.3.3 Policy impacts on externalities

The issue of GMOs covers a wide range of concerns, including public health, environmental and biodiversity protection, development, and trade (Sägesser, 2001). Assessing the impact of GMOs in the food sector on human health and the environment is a complex task due to the diverse nature of GMOs. To date, there is limited literature on the causal effects of GMOs, particularly on the specific effects of a ban. In this review, we focus on examining the effects of banning MON810 and other insect-resistant GM crops on intended externalities, excluding herbicide-resistant GMOs such as glyphosate.

1.2.3.3.1 Environmental and biodiversity externalities

[22] The report predicts an average 19% increase in the price of corn, resulting in a 16% increase in the price of tortillas, a staple food. This predicted increase is worrisome because 10% of Mexicans already struggle with access to food.

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One of the primary concerns associated with GM crops is their potential environmental and biodiversity impact (Sägesser, 2001). When considering the implications of a GMO ban on the environment and biodiversity, various hypotheses arise, depending on the specific externalities considered.

1.2.3.3.1.1 Gene transfers and outcrossing externalities

A ban on GMOs such as MON810 can help prevent genetic pollution, a phenomenon where gene flow occurs from GM crops to neighboring non-GM crops or wild relatives via pollen (Fitzpatrick and Reid, 2019; Oehen et al., 2018). Gene flow, which can occur over distances of 50m to 100m (Carrière et al., 2021), could lead to environmental risks such as the emergence of resistant weeds and the unintended spread of GMOs, possibly resulting in biodiversity loss (Haile et al., 2020).[23]

1.2.3.3.1.2 Biodiversity

Transgenic crops, also known as insect-resistant crops, have sparked an ongoing debate about their potential irreversible impact on biodiversity (Hernandez-Lopez, 2022; Orsini, 2012; Dobe and Sen, 2009). In the case of a *Bt* corn ban, the consequences are complex and controversial with both positive and negative impacts on biodiversity.[24]

Implementing a ban on MON810 may provide significant benefits in terms of crop diversity, non-target species, and area-wide pest suppression (Carpenter, 2011). GM *Bt* corn plants can harm beneficial insects such as green lacewings (*Chrysoperla carnea)*, which are essential for controlling corn pests (Andow and Hilbeck, 2004; Obrist et al., 2006; Harwood et al., 2005; Lövei and Arpaia, 2005). The monoculture associated with GM crop cultivation brings the risk of herbicide tolerance and insecticide resistance, possibly leading to disruptions in the food chain. A ban also plays a pivotal role in preserving genetic diversity, preventing an irreversible loss that could occur due to the release of GMOs (Dobe and Sen, 2009).

Since the late 1990s, one of the most emblematic cases of the unintended effects of GM *Bt* corn toxins on non-target organisms (Picard-Nizou et al., 1995; Arpaia, 1996; Hilbeck et al., 1998; Birch et al., 1999; Bell et al., 2001; Losey et al., 1999) has been lepidopteran insects, including the Monarch butterfly (Lepidoptera: Danaus plexippus*)* in North America. Moreover, another laboratory research by Hilbeck et al. (2012) reveals adverse impacts of Cry1Ab, a variant of maize MON810, on ladybirds (Coleoptera:

[23] A GMO ban may also internalize negative effects of GM0s on genetic diversity itself. Indeed, GMOs can transfer genetic material from GM foods to human cells or gastrointestinal bacteria, a process known as horizontal gene transfer (HGT). This is particularly evident when GMO production involves the use of antibiotic resistance genes. GMOs can gain a competitive advantage over their (non-GM) wild relatives by acquiring beneficial genes, resulting in accelerated growth, and enhanced reproductive capabilities (Vogan and Higgs, 2011). However, this process also has certain drawbacks, as it can impose costs by potentially enabling GMOs to outcompete non-GMO relatives and deplete shared resources, which can come at a cost to the overall ecological balance.

[24] In the European Union and elsewhere, environmental risk assessment of *Bt* crops focuses solely on acute toxicity, neglecting effects on higher organisms. This limited approach does not consider the broader consequences. For example, green lacewings are negatively affected by the toxicity of *Bt* crops through their prey. Criticism of this direct risk assessment method is widespread, with many scientists advocating comprehensive studies of the effects of *Bt* crops throughout the food chain (Andow and Zwahlen, 2006; Snow et al., 2005; Knols and Dicke, 2003).

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Coccinellidae). Over time, however, these studies have remained the subject of scientific controversy and uncertainty (see Appendix 1A.2 for the case of the Monarch butterfly).

On the contrary, there is growing concern about the potential negative impacts of a GMO ban on biodiversity, particularly because of increased pesticide use. Indeed, the literature suggests that GM crops may mitigate biodiversity risks by switching from pesticides to *Bt* crops, thus benefiting non-target insects in experimental fields (Ammann, 2005).

1.2.3.3.1.3 Soil ecosystems

A MON810 ban may have a negative impact on soil ecosystems. Since *Bt* crops release their toxins from their roots into the soil (Saxena et al., 2002), active *Bt* toxin is also found in crop residues left in the field (Flores et al., 2005; Stotzky, 2004; Zwahlen et al., 2003). Despite the existence of these potential routes of environmental exposure, the cumulative long-term effects of *Bt* maize cultivation have not yet been thoroughly assessed in a European context.

1.2.3.3.1.4 Land use change and greenhouse gas emissions

The MON810 ban in France may have a limited impact on greenhouse gas (GHG) emissions and land use change due to the small amount of initial GM UAA before the ban. However, very few studies have examined the impact of the MON810 ban, indicating a clear need for in-depth empirical research on this topic (Burney et al., 2010; Mahaffey et al., 2016). The main impact on land use is related to changes in crop yields, and changes in land use may in turn affect GHG emissions. In fact, the introduction of these GM *Bt* corn traits allows farmers to maintain or increase yields without expanding cropland, thereby reducing the pressure for land-use change and the associated carbon emissions from deforestation or land conversion. On the contrary, by forcing farmers to revert to traditional, lower-yielding corn varieties, banning MON810 could increase demand for agricultural land and accelerate deforestation or land conversion (Burney et al., 2010).

This negative impact on land use and greenhouse gas emissions have been found in Europe (Mahaffey et al., 2016). They show that the implementation of a ban worldwide may lead to a significant conversion of land to cropland, resulting in a global increase of about 3.1 million hectares.[25] Of this, about 2.5 million hectares would be converted from pasture, while about 0.6 million hectares would be attributed to global forest loss, including areas in Europe. The absence of GMO technology may have a significant impact on greenhouse gas emissions, contributing to an estimated additional 0.9 billion metric tons of CO_2 equivalent emissions from land use change worldwide. It is important to note that these figures represent a substantial increase in GHG emissions compared to current levels.

[25] In this case, the ban should mainly have an effect in Spain and Portugal (see Section 1.2.1).

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A second effect on greenhouse gas emissions is related to the pest resistance offered by MON810, which reduces the need for synthetic pesticide applications. The production and application of these agrochemicals contribute significantly to greenhouse gas emissions. As shown by Brookes and Barfoot (2017), the adoption of GM insect-resistant crops has led to a significant reduction in pesticide use worlwide, amounting to an environmental saving of 671.4 million kg of active ingredient between 1996 and 2015. By banning GM maize, France could potentially see an increase in pesticide use if other pesticide-free agricultural practices are not adopted, contributing to an increase in associated GHG emissions.

In addition, the potential lower yields following the MON810 ban could lead to an increase in nitrogen fertilizer and pesticide application rates to compensate for the yield loss. As nitrogen fertilizers are a major source of N2O, a potent greenhouse gas, this could further increase greenhouse gas emissions.

1.2.3.3.2 Health and social externalities

1.2.3.3.2.1 Impact on public health outcomes

The French ban specifically targets the cultivation of GMOs without restricting the import of GMO consumer products. The MON810 ban therefore has no direct impact on food consumption. The only effects are related to the avoidance of cross-contamination between GM and non-GM crops and the exposure of agricultural land to the increased use of pesticides to control pest outbreaks such as the European corn borer. Thus, the health impact of the ban on consumers may be limited.

1.2.3.3.2.1.1 Farmland exposure of farmers and households

A ban on MON810 could require increased pesticide use as an alternative solution for pest resistance, a benefit typically offered by GM crops. This could make farming more complex and increase exposure to pesticides for both farmers and nearby households. The increased risk is due to more frequent handling and application of pesticides and increased levels of insecticide residues in harvested crops (see the Section on the public health impact of pesticides for more details).

1.2.3.3.2.1.2 Food consumption and safety

The effects of a GMO ban on food consumption and safety are difficult to measure because of the different types of substitution and the unexplored causal health effects of GM foods.

On the one hand, in terms of food consumption, the MON810 ban may have broader implications beyond the documented agronomic and economic disadvantages, potentially reducing food safety. The potential risks to human health usually raised in the context of GMOs are food toxicity and allergenicity (Christou et al., 2013; Sägesser, 2001), caused by the gene of interest itself (which may contain DNA from allergenic species) or by the use of certain marker genes (for antibiotic resistance) (Sägesser, 2001). To date, there has been no causal evaluation study that provides evidence that *Bt* toxins do or do not pose a risk to human health. While the absence of short-term toxicity suggests immediate safety, it does not rule out potential long-term effects that may develop over time. Furthermore, there is no substantial evidence to support a causal relationship between GMOs and food allergies (Xu, 2015).

Furthermore, the MON810 ban can improve consumer safety by preventing accidental contamination of conventional fields with GMOs. Before the French ban, despite the negligible prevalence of GMO-converted land, the risks of such contamination were amplified due to inadequate coexistence measures for GM and non-GM crops. At that time, the health risks could materialize directly through the consumption of GMOs or indirectly through the consumption of contaminated conventional products or any product derived from animals that have ingested GMOs.

On the other hand, the ban could lead to increased pesticide residues in food (Authority et al., 2022), as well as reduced seed protection against insects, poorer grain health, and increased contamination of crops and food with carcinogenic mycotoxin-producing fungi.[26]

1.2.3.3.3 Impact on social externalities

Genome modification has been used for decades in medicine and agronomy, but recent advances in technology have raised **ethical concerns** about its applications (Oliver, 2014). In particular, the incomplete understanding of GM techniques underscores uncertainties regarding their impacts on individuals and biodiversity. Consequently, proponents of a ban on GMOs argue that such a ban could serve as a precautionary measure to allow for further research and assessment of potential impacts before widespread implementation, but also to eliminate any unintended consequences for future generations.

1.2.3.3.4 Economical externalities

The French GM ban may have an impact in terms of **opportunity costs** and a long-term effect on future innovation in biotechnology and the development of new genetic traits. Literature suggests that a GMO ban may hinder the development of new breeding techniques (World Perspectives, Inc. & Arlington, VA, 2022). However, while the commitment to GMOs has not been prioritized in the EU, other regulations such as agroecology, pesticide bans, etc. are putting efforts into resilience, environmental protection, and related areas.

[26] To provide insight, Pellegrino et al. (2018) conducted a meta-analysis of the scientific literature up to 2016, focusing on GMO corn and the issue of mycotoxins affecting cereal crops. Their results showed that transgenic corn contains 28.8% fewer mycotoxins compared to non-GMO lines.

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Appendix 1A: Genetically Modified Organisms

1A.1 Regulatory Framework in France

France adopted disputed EU laws on GMO crop growing in 2007 and was fined 10 million by the European Court of Justice for the six-year delay in implementing the laws. At the heart of this framework is **Law No. 2008-595 of June 25, 2008**, on the administrative and scientific coordination of biosafety. This law establishes an autonomous evaluation mechanism known as the ***Haut Conseil pour les Biotechnologies*** (High Council for Biotechnology, HCB). To implement European Directive 2001/18/EC, the law of June 25, 2008 provides a comprehensive regulatory framework for the cultivation of GMOs. The law achieves this by clarifying responsibilities within a liability framework and establishing the principle of information and insurance conditions in the context of coexistence between GM and non-GM crops through technical specifications and spatial segregation requirements. This law was repealed at the same time as the ban came into force. **Decree No. 2019135** introduced amendments to the Environmental Code, designating the competent regulatory body responsible for issuing authorizations, defining the requirements for the technical dossier, and granting authorizations for food, feed and food contact materials.

Following the ***Grenelle de l'Environnement***, a consultation process held during the political campaign for the 2007 presidential election, the French government invoked the safeguard clause and imposed a moratorium to ban the cultivation of MON810 in February 2008. This decision was prompted by concerns of the independent authority HCB assessment committee, and expressed "serious doubts" about the safety of the product. In 2011, both the European Court of Justice and the French Conseil d'État ruled that the French Ministry of Agriculture's ban on MON810 was unlawful because it failed to demonstrate the existence of a particularly high risk to health and the environment. Following the publication of the study by Hilbeck et al. (2012) on the impact of MON810 on biodiversity, the French government justified the implementation of urgent precautionary measures due to the upcoming sowing season. On June 2, 2014, the French government intended to implement **Law No. 2014-567**, which would have imposed a new ban on the cultivation of genetically modified maize. However, the Conseil d'État annulled these measures for the second time for non-compliance with European law (Decree of 14 March 2014). This decision followed the rejection of the French government's arguments by the EFSA, calling the decision "scientifically unfounded" (EFSA, 2012). On September 17, 2015, the French government announced its intention to maintain its ban on GMOs, using the "opt-out" provision agreed by 28 EU member states six months before. France has requested permission from the European Commission to extend the ban to nine additional maize varieties.

1A.2 A case of scientific controversy: The Monarch Butterfly and *Bt* corn

Monarch butterfly larvae, reliant on milkweed leaves as their primary food source, could potentially consume *Bt* corn pollen deposited on milkweed leaves near cornfields.

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In a paper published in Nature in May 1999, Losey et al. (1999) investigated the impact of exposing monarch butterfly larvae to leaves coated with *Bt* pollen. The study finds that caterpillars exposed to *Bt* pollen experienced slower growth and higher mortality compared to those consuming non-transgenic maize pollen. However, the study did not specify the exact quantity of pollen consumed by the caterpillars. Another study from the University of Iowa (Hansen and Obrycki, 2000) confirmed increased caterpillar mortality when fed milkweed leaves collected near *Bt* cornfields (Hansen and Obrycki, 2000). Further research has challenged the initial findings, demonstrating that the risk to Monarch larvae from ingesting *Bt* corn pollen is negligible and that *Bt* corn provides a safer environment than chemical insecticides. It was concluded that the dispersal of *Bt* corn pollen, the density of toxins on milkweed leaves near fields, and other factors pose minimal threat to Monarch caterpillars in their natural environment. In addition, Monarch larvae do not consume enough pollen in their natural environment to be affected by *Bt* toxins. However, prolonged exposure to *Bt* corn pollen has been shown to affect the behavior (Prasifka et al., 2007) and survival (Dively et al., 2004) of the Monarch butterfly.

There are limited studies on the effects on European butterflies, but concerns have been raised about the consequences of insect-resistant crops for these species (Lang and Vojtech, 2006; Darvas et al., 2004; Felke and Langenbruch, 2003; Felke et al., 2002).

2 Food security and nutrition

2.1 Nutrition

Key findings

- Overweight and obesity, especially among children and adolescents, are rapidly increasing health challenges globally and in the European Union. These conditions are linked to many health risks including noncommunicable diseases, cancers, and mental health disorders, and are primarily caused by excess calorie intake from poor diets and reduced physical activity levels.

- Policy measures, such as France's National Nutrition and Health Programme, have been implemented to promote healthier lifestyles and diets, but have proven insufficient to reverse obesity trends. Recent policy adjustments include taxes on sugar products and front-of-pack labelling.

- Global sugar overconsumption has led to policy debates on taxing sugar-sweetened beverages (SSBs) to reduce public health risks. Various types of taxes, such as excise and ad valorem, are used globally to discourage SSB consumption. The effectiveness of these taxes depends on their design, level, and impact on the food chain. Globally, over 54 countries have implemented soda taxes. The French soda tax, which applies to all non-alcoholic beverages with added sugar or synthetic sweeteners, was introduced in 2012 and later revised in 2018 to a progressive system based on sugar content.

- The implementation of a SSB tax impacts market prices, incentivizes product reformulation, and affects public awareness, thereby influencing consumer behavior and health externalities. Its effectiveness varies based on the pass-through rates, tax design, and public awareness levels.

- Studies suggest that the implementation of the soda tax in France has led to a modest short-term reduction in soda consumption. The effects are complex due to factors such as product substitution, tax design, and differences in consumer behavior. The French 2018 tax reform, due to its progressive design, may have a larger impact on consumption and product sugar content reduction due to its progressive design.

- Nutrition labeling, both back-of-pack and front-of-pack, provides consumers with accurate information on the nutritional content of food, aiding their understanding of nutritional value, and promoting healthier choices.

- Launched in France in 2017, the Nutri-Score system has experienced significant adoption, capturing a 58% market share of sales volume in 2022.

Its usage has also expanded to several other European countries. The system evaluates food products on a scale from A (healthiest) to E (least healthy), thereby enabling consumers to make more informed choices and exerting pressure on food manufacturers to improve the nutritional quality of their products.

- The Nutri Score labeling system affects diet and health outcomes by influencing product reformulation and innovation for healthier options, potentially influencing market prices, and improving public awareness of healthier eating behaviors. However, its effectiveness may be limited by its voluntary nature, potential increase in consumer prices, and variability in consumer understanding and acceptance of the label.

- The Nutri-Score labeling system has demonstrated effectiveness in improving consumer food choices and promoting healthier alternatives, although its real-world impact on the overall nutritional quality of purchases and health outcomes remains limited.

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Overweight and obesity, particularly among children and adolescents, have been identified as a major public health challenge globally and in the European Union (EU). The incidence of overweight and obesity is increasing at a rapid rate and has doubled in the last 30 years in most of the EU Member States (Yadav et al., 2009).[27] One in three school-aged children, one in four adolescents and almost 60% of the adult population are now overweight or obese in the EU (Ogden et al., 2014; WHO, 2022; Figure 2B.1). In France, 32.3% of adults aged 18 years and older were overweight and 15% were obese, compared with 14.5% in 2009, according to the Obépi-Roche national epidemiological survey launched in 2012 (Obépi, 2012). This difference represents a relative increase of 3.4% in the number of obese people over the last three years. Despite a downward trend (+18.8% between 1997 and 2000, +17.8% between 2000 and 2003, +10.1% between 2003 and 2006, and +10.7% between 2006 and 2009), obesity rate continue growing. In 2020, 17% of the French population suffer from obesity, including 1 million in a situation of morbid obesity, yet the share of obese adults in France is lower than the European average.

Obesity is a complex multifactorial disease defined by excessive adiposity that presents a risk to health (WHO, 2022). Raised body mass index is a major risk factor for noncommunicable diseases (NDC), including at least 13 different cancers[28], cardiovascular diseases and cardiometabolic disturbances (Vos et al., 2017; WHO, 2022), arthritis (Scimeca et al., 2016), mental health disorders and obesity during adulthood (Daniels et al., 2005; Crume and Harrod, 2013). Multiple metabolic diseases comprise type 2 diabetes mellitus (Anderson et al., 2003), due to high-level blood glucose, deficient insulin secretion, and insulin resistance (Malik et al., 2010; Imamura et al., 2015; Li et al., 2022), NCDs compromise well-being and are a widespread cause of premature death as well (Global Burden of Disease Collaborative Network, 2012).

In most cases, obesity is the result of an unbalanced caloric intake due to excess of calories that the body stores. This excess of calories comes mainly from poor diets with ultra-processed foods high in added saturated fats, added sugars (Poti et al., 2015; WHO, 2015; Vartanian et al., 2007; Te Morenga et al., 2012; Wang et al., 2015), combined with reduced physical activity levels (Chin et al., 2016; Cassidy et al., 2017). High-fat diets, obesity and overweight, represent a social burden, as they have a substantial long-term cost to society, not only in terms of social impact but also economically. These health problems generate significant healthcare costs and affect overall productivity (OECD, 2019). According to a peer-reviewed study by the World Obesity Federation and RTI International (Okunogbe et al., 2022), the economic impact of overweight and obesity is estimated to rise from 2.19% of GDP in 2019 to 3.3% in 2060 (if current trends continue) in 161 countries (Figure 2B.2). The countries expected

[27] Overweight and obesity are defined through the Body Mass Index (BMI) which is the weight (in kg) divided the square of height (in m). An individual is overweight when his BMI ranges between 25 and 30 and is obese when his BMI is greater than 30.

[28] According to the World Cancer Research Fund International's Continuous Update Project, obesity is considered a cause of cancers including bowel (colorectal), gallbladder, kidney, liver, oesophagus, ovary, pancreas, prostate (advanced), postmenopausal breast and womb (endometrial). Access on the website: https://www.wcrf.org/diet-activityand-cancer/global-cancer-update-programme/about-the-global-cancer-update-programme/ [Last access: May 9th, 2023].

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to have the largest economic cost[29] of overweight and obesity are China (over $10 trillion), the United States (over $2.5 trillion) and India (nearly $850 billion) (Shekar and Popkin, 2020; Okunogbe et al., 2022; Chen et al., 2021). Other countries with the economic costs of overweight and obesity projected to exceed $100 billion include Germany, Canada, Australia, Brazil, the United Kingdom, and Japan. In France, Caby (2016) estimates that the social cost of obesity was around €20bn in 2012, comparable to that of tobacco and alcohol, and is expected to reach $133 billion (2.29%GDP) by 2060 (Okunogbe et al., 2022). These findings underscore the need and urgency, from a social and public finance perspective, to allocate resources as quickly as possible to both the collective and individual prevention of obesity and the effective treatment of overweight and obesity.

Policymakers hold a crucial responsibility and must therefore implement measures to promote healthier lifestyles and diets (OECD/FAO, 2020). France has tailored the National Nutrition and Health Programme (*Plan National Nutrition Santé*, PNNS) to address public health issues. This initiative was launched in January 2001 as a multi-sectoral public health program coordinated by the Minister of Health at the request of the French Prime Minister (Chauliac, 2015). The PNNS aims to *"improve the health of the entire population by acting on one of its main determinants: nutrition (including diet, physical activity and sedentary lifestyle)".* The program has been renewed three times, with PNNS 2 in 2006, PNNS 3 in 2011 and PNNS 4 in 2019. PNNS 4, published in September 2019 for four-year period (2019-2023), prioritizes environmental actions and health-promoting behaviors, with a focus on reducing social inequalities. It aims to achieve the health goals set by the High Council of Public Health through 55 actions, including including reducing obesity by 15% and stabilizing overweight in adults, reducing overweight and obesity in children and adolescents by 20%, and reducing malnutrition in the elderly by at least 3% for those over 80 (Ministère des Solidarités et de la Santé, 2019).

Most policy interventions initiated by the different PNNS were information campaigns or charters in television programming and advertising to promote healthy eating and behavior, but these have proved insufficient to reverse rising trends in obesity and diabetes (Chauliac and Hercberg, 2012; Sebillotte, 2019). Recently, France has implemented policies to tax sugar products that contribute most to the sugar intake of children and adolescents, limited to sugar-sweetened beverages, front-of-pack labelling and school policies.

2.1.1 Tax on sugar-sweetened beverages

2.1.1.1 Introduction

The amount of sugar consumed sharply increased over the last 50 years and the population today tends to consume too much sugar. Children in Western Europe

[29] Total economic costs including estimated direct and direct costs. Figure 2B.3 displays the cost components framework and corresponding mechanisms.

consume from 16% to 26% of total energy intake from added sugars (Azaïs-Braesco et al., 2017). After the United States, Germany is the world's second-largest consumer of sugar, consuming 102.9 grams of sugar per person per day. The Netherlands (102.5 grams) and Ireland (102.5 grams) come respectively third and fourth on this list. According to the WHO (2015), the recommended limit for the daily dose of free sugar, including added sugars, should be limited to less than 10% of daily calories for improved health (equivalent to 11 grams, or 2.75 tsp.[30]), with WHO also recommending that this number not exceed 25g per day (5.75 tsp.). This sugar overconsumption is mainly due to the "hidden" sugars in foods processed by the food industry. Sugar-sweetened beverages (SSBs), sweets, desserts, cakes, biscuits, beverages and dairy products are the main foods with high sugar Intakes. Among sugary food products, SSBs present high added sugar content, low satiety, and incomplete compensation for total energy. In Europe, 1/6 European adolescents consume soda every day, contributing to the evidence-based 'epidemic' of obesity (Harnack et al., 1999; Malik et al., 2006). Because of the increasingly pressing public health issue, the World Health Organization (2016) has discussed ways to regulate and discourage the consumption of SSBs through economic instruments, mainly tax incentives for nutrition.

Fiscal policies, such as taxes on harmful or unhealthy products (or alternatively, subsidies on healthier goods), are often applied to "sin products" like cigarettes, alcoholic beverages, and sugary drinks. "Sin taxes" are a widely used policy tool aimed at discouraging overconsumption (Bonnet and Réquillart, 2013a; Allcott et al., 2019), and improve social welfare in a corrective logic dating back to

Pigou (1920) and Diamond (1973). Consumption of these goods can generate *externalities*, such as health care costs or pollution. Over the past two decades, behavioral economics research has argued that taxes can discourage consumption of goods that impose unaccounted costs on one's future self, commonly referred to as internalities and arise from cognitive biases such as self-control problems, inattention, and incorrect beliefs. These internalities can lead to excessive consumption of sin goods, as demonstrated by Gruber and Köszegi (2004), O'Donoghue and Rabin (2006), Haavio and Kotakorpi (2011) and Allcott et al. (2014).

Ideally, we would have individual taxes correcting for everyone's contribution to externalities and internalities which can both differ across consumers. In a real-world individualized taxes cannot be implemented. What is more, equity considerations are usually considered of utmost importance and used as support of the usual argumentation that sin/soda taxes are regressive.

A tax will change consumption if demand is responsive to price changes. As a general rule, the higher the elasticity of demand the higher the corrective power of a tax. On the other hand, lower income individuals may consume disproportionally more sodas and therefore a soda tax may be regressive. Also, they may be less responsive to a tax (less elastic demand) in which case their consumption behavior may not change much with a tax.

[30] This is also equivalent to 6 pieces of sugar for adults and 3 pieces for children.

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The optimal corrective tax needs to consider both the externalities and balance the correction of internalities with redistributive purposes (Allcott et al., 2019; Licari and Meier, 2000). In other words, the optimal policy should be aimed primarily at reducing the purchases of those whose marginal consumption is the most biased and contributes the most to externalities yet considering their demand respond to taxes and redistributive concerns. Increasing the price of sugary products may enhance welfare by getting people to take these internalities and externalities into account Griffith et al. (2019).

We can distinguish different types of tax (World Cancer Research Fund International, 2018). *Excise taxes* are typically levied on specific goods or services, such as tobacco, alcohol, or gasoline. They may be based on either the quantity of the taxed product (e.g. per liter of soda), or on the amount of a specific ingredient (e.g per gram of sugar). *Ad valorem taxes*, on the other hand, are calculated as a percentage of the value of the product being taxed. The choice between these two types of tax, or a mix of both, depends on factors such as administrative capacity, political feasibility, and desired impact on consumer behavior. For instances, ad valorem taxes can be easier to administer than excise taxes because they do not require detailed information about the quantity or volume of products sold. However, they may not be as effective in discouraging consumption because they do not raise the price of cheaper products as much.

The efficiency of a tax depends on its type, its design (proportional or progressive), its level and its transmission along the food chain. For example, Bonnet and Réquillart (2013b) show that an excise tax is more transmitted than ad valorem tax on consumer prices.

Globally, since 2012, soda taxes have been implemented in over 54 countries around the world, including in Europe and some cities in the United States and Mexico (Figure 2.1). In Europe, taxes on soft drinks are currently implemented in the UK, Ireland, Belgium, Hungary, Norway, Portugal, Catalonia (Spain), and Finland.

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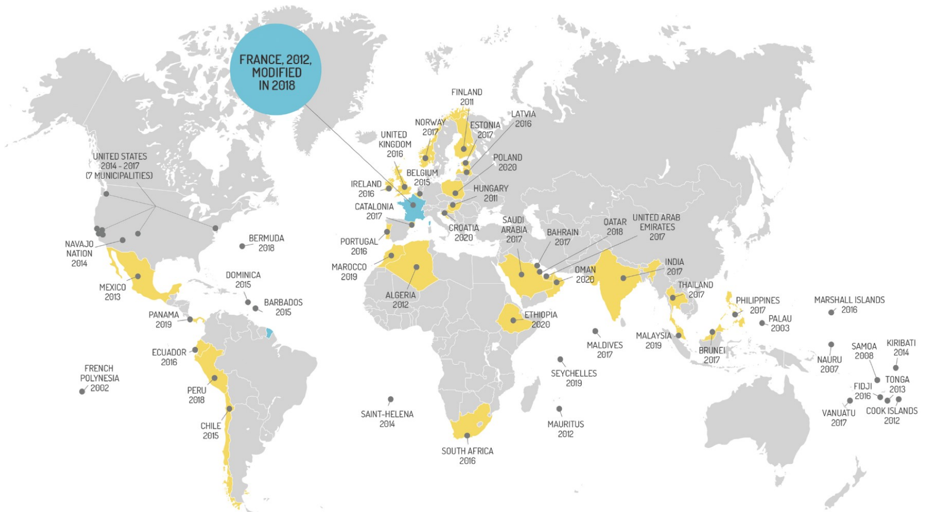

Figure 2.1: Taxes on non-alcoholic beverages

Notes: Figure 2.1 shows health-related taxes on non-alcoholic beverages adopted around the world (end of 2020). Source: Le Bodo et al. (2022).[31]

2.1.1.2 Soda tax in France

The National Nutrition and Health Program of 2011 (PNNS-3) sets a target to improve the distribution of sugar intake from non-alcoholic beverages. In particular, it aims to reduce the proportion of children consuming more than half a glass of soda per day by at least 25% within the next five years (Ministère du Travail, 2011, pp.13-14). At that time, the French government was also forced to find alternative sources of revenue that would not significantly affect consumers and economic operators especially the agricultural sector which was struggling with high labor costs–- due to the prevailing economic crisis (Le Bodo et al., 2019, 2022).

In this context, a soda tax was introduced in the 2012 French Budget Law No. 2011-1977 and came into force in January 2012 on all non-alcoholic beverages with added sugar (e.g soft drinks) or synthetic sweeteners (e.g. diet drinks), such as sodas, but also flavored waters and fruit drinks.[32] Table 2.1 describes the soda tax for France compared to the United Kingdom, Catalonia, Portugal and Hungary. Discussions on its introduction lasted from 2005 to August 2011 (Le Bodo et al., 2019). This tax has caused many controversies before the validation of the Parliament. Initially, the measure consisted of creating a tax of 3.6 euros per hectolitre and apply only to sweetened drinks (excluding

[31] See the Obesity Evidence Hub website for a list of the 54 countries that have implemented a tax on SSBs, with details on implementation date and type of tax used, including tiered tax designs based on sugar content. Access here: https://www.obesityevidencehub.org.au/collections/prevention/countries-thathave-implemented-taxes-on-sugar-sweetened-beverages-ssbs.

[32] Table 2A.1 lists the SSBs covered by the French soda tax. Infant formula and soy beverages are excluded.

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diet versions that contain artificial sweeteners). The soft drink market in France is an oligopoly with only four groups sharing a large part of market shares: Coca Cola, Orangina Swcheppes, Pespico and Unilever. Under the opposition of the National Association of Food Industries (ANIA), but also of the two big leaders Coca-Cola and Schweppes-Orangina,[33] the government finally decided to double the tax and apply it to all drinks, whether sweetened or with sweeteners.[34] The excise amounts to 7.16 cents per liter on soft drinks (sugar-based or diet), suggesting that the main objective is to raise revenue from taxation (Bonnet and Réquillart, 2013b).

Aiming the reduction of obesity rates, the soda tax was amended in July 2018 as part of the 2018 Social Security Financing Act to encourage the production and the purchase of healthier beverages. The French **Law No. 2017-1836** provides for a progressive tax based on the added sugar content of the beverage, that is, the more sugar in the beverage, the higher the tax, with products containing more than 11g of sugar being taxed at 20 cents per liter and the tax rate increasing progressively up to this maximum tax. Such a progressive tax structure aimed to achieve two main objectives. First, to ensure a fair distribution of the tax burden based on its impact on inequalities in sugar consumption. Second, to avoid economic distortions and efficiency losses associated with marginal and average tax rates, which are key determinants of incentive effects (see Art. 19 of the above-mentioned Law: "avoid[ing] threshold effects through a more progressive increase"). Figure 2.2 shows how the tax rate varies with the amount of added sugar.

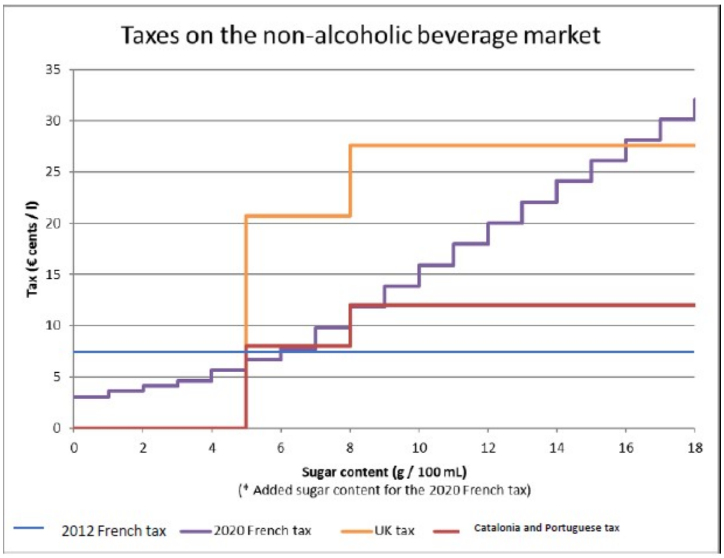

Figure 2.2: Comparison of taxes implemented in the non-alcoholic beverages markets in France, the UK, and Catalonia

[33] At the time of the reform, Coca-Cola threatened to relocate its factories, while Schweppes-Orangina felt that the exemption of soft drinks favored the American giant, which was very present in this segment of the market.

[34] Source: https://www.lemonde.fr/economie/article/2011/12/29/la-taxe-sur-les-boissons-sucrees-entrera-bien-envigueur-au-1er-janvier_1624009_3234.html [Accessed on March 28th, 2023]

For example, a 33-centiliter can of Coca-Cola would rise from 46 cents (with the original tax rate) to 53 cents (post amendment). Fanta Lemon, which is less sweet, stays the same at 47 cents, while less sweetened beverages, such as flavored water e.g. lemon-flavored Volvic could fall from 57 to 53 cents. Less sweetened beverages, such as flavored waters, should now be taxed very little. Tax rates are updated annually by the French Ministry of Economy. For 2023, Article 1613 ter of the General Tax Code (*Code general des impôts,* CGI) revalues the tax at 3.17€ per hectolitre on January 1, 2023 (compared to 3.12€ in 2022, 3.11€ in 2021 and 3.08€ in 2020). Non-alcoholic beverages containing synthetic sweeteners were also affected by the update of the law (Art.1613 quater, II-2° of the CGI).[35], since they are not taxed anymore.

2.1.1.3 Mechanisms of the instrument for internalization

Figure 2.3 illustrates the effect pathways from implementation of a SSB tax to changes in health externalities. The remainder of this section describes each pathway in detail. First, we show how the soda tax impacts market prices. We then describe the potential incentives of the tax to reformulate products. Finally, we discuss the role of public awareness and its impact on the purchase and consumption of SSBs.

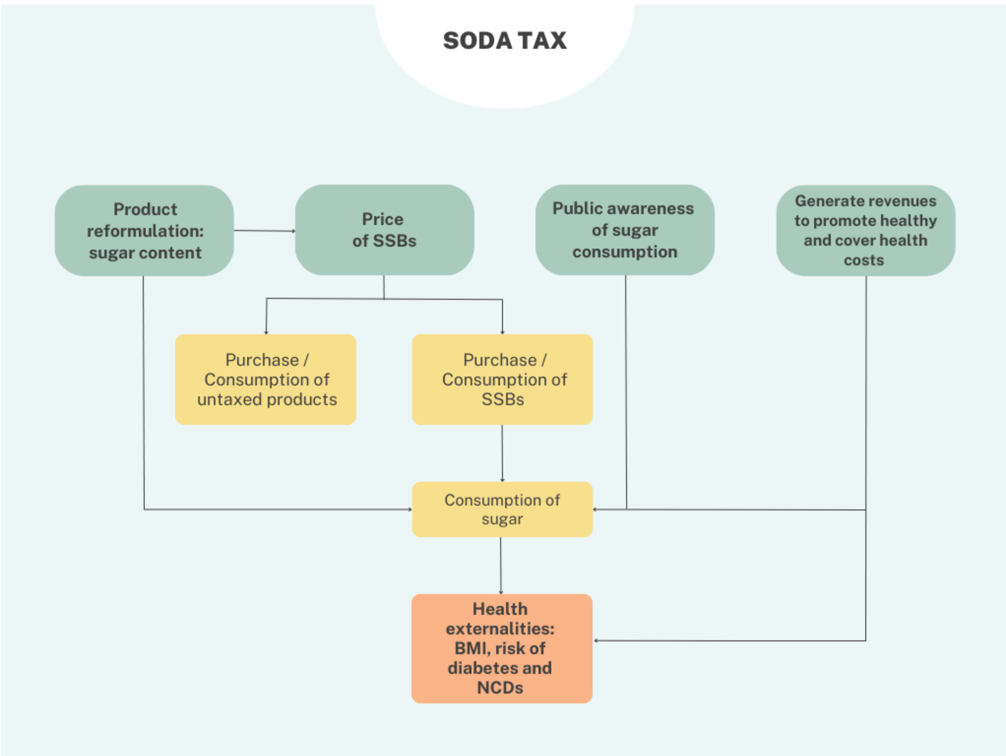

Figure 2.3: Pathways of Effects

[35] Source: https://bofip.impots.gouv.fr/bofip/13747-PGP.html/ACTU-2022-00146

Juridiction	Implemented	Base	Design	Rate	Tax subject to VAT
UK	April 2018	Drinks containing added sugar	Two tiered tax	0-<5g sugar/100ml: no tax 5–8g sugar/100ml: 18p/litre >8g sugar/100ml: 24p/litre	
Catalonia, Spain	May 2016	Drinks containing added sugar	Two tiered tax	0-<5g sugar/100ml: no tax 5-8g sugar/100ml: 0.080€/l >8g sugar/100ml: 0.120€/l	yes (10%)
France	January 2012	Drinks containing added sugar or artificial sweeteners	Flat tax	0.753€/l	yes (5.5%)
	September 2018		Progressive	15 thresholds (*see* Figure 2)	
Hungary	2011	Drinks containing sugar-sweetened	Sales tax	>8g sugar/100ml: 5HUF/l	
Portugal	February 2017	Drinks containing added sugar or artificial sweeteners	Two tiered tax	0-<5g sugar/100ml: no tax 5-8g sugar/100ml: 0.080€/l >8g sugar/100ml: 0.120€/l	

Source: Based on information from Gellynck et al. (2014); Gangl (2021); Allais et al. (2021); World Cancer Research Fund International (2018). Conversion of Hungarian Forint (HUF) to Euro using the exchange rate of March 28, 2023 (1 HUF=0.0026€). Conversion of rates to euros per litre values are based on currency conversion rates on 28 March 2023: 1p=1.09€ cent and 1 HUF = 0.0026€.

Table 2.1: Description of some taxes implemented in the non-alcoholic beverages markets in Europe

2.1.1.3.1 Pass-through to prices

By law, the tax burden is borne by the consumer who pays the retail price including the soda tax (Ecorys, 2014), but the government collects the tax at the manufacturer level. The effect of the soda tax on market price will depend on strategic pricing decisions of manufacturers and retailers, that could under or over-transmit this additional cost to consumers prices. *Over-shifting*, where prices increase by more than the tax amount (pass-through rate greater than 1), may be desirable, while *under-shifting*, where manufacturers and retailers absorb part of tax (pass-through rate lower than one), is less desirable. Structural econometric analyses of the transmission of cost shocks in the French Soft drink industry have shown mixed results on pass-through rates.

Etilé et al. (2018) provide empirical evidence of a partial pass-through of 39% while Bonnet and Réquillart (2013b) estimate an average pass-through between 116% and 122%. Those opposite results are mainly explained by the econometric method used. However, according to Campa and Goldberg (2006), in France, cost shocks are expected to be over-transmitted by the food sector compared to other countries or other industries. Additionally, Bonnet and Réquillart (2013b) show that the pass-through rate varies across retail groups and beverage brands. Applying a difference-in-difference approach to data with over 500,000 non-alcoholic beverages from drive outlets, Berardi et al. (2016) compare the change in the price of taxed drinks with the change in the price of water between August 2011 and June 2012 (that is, before and after the introduction of the soda tax). The authors find a heterogenous pass-through across product types, brands and retailing groups. depending on the product type, with taxes on private label and small producer brands generally over-shifted. The average price of soda drinks rose by 7.55 cents per litre, the tax was fully after 6 months, while being significantly over transmitted to consumer prices. Prices of fruit drinks and flavored waters increased respectively by 7.1 and 4.7 cents per liter, highlighting an incomplete pass-through (94% and 62%, respectively). Capacci et al. (2019) also examine the effects of the introduction of the French soft drink tax on prices and purchases of soft drinks (excluding fruit juices) and fruit juices. The authors find similar results using two distinct databases: household-level scanner data and consumer price indexes from INSEE (France) and ISTAT (Italy). They conduct a difference-in-difference approach using two alternative control groups, either two nearby regions in Italy or water. The authors shows that there have been changes in prices for taxed beverages, with an average increase of €0.05-0.09 which corresponds to an increase from 4.9% to 9% of the price of taxed beverages. Those results indicate both under and over transmission depending on the type of products.

2.1.1.3.2 Product reformulation and innovation

Manufacturers can also reformulate products and decrease their sugar content to mitigate the impact of price increase or totally avoid the tax. The 2012 tax on volume could not provide any incentives for reformulation as the tax rate was independent of the amount of sugar content. Indeed, in France, industry stakeholders interviewed state that the tax has not led to a reformulation trend in 2012 (Ecorys, 2014). On the contrary, the 2018 progressive sugar content tax, was followed by a 6% sugar reduction of products in 2018 compared to 2017 and a lower price increase in SSBs than in the past (Allais et al., 2023).

As a comparison, the UK tax designed as a two-tiered tax (with 3 thresholds) with larger tax rates allowed reduction of sugar content of 31% in 2019 compared to 2015. It highlights the design of the tax is crucial to provide stronger incentives as possible through the food value chain (Allcott et al., 2019).

2.1.1.3.3 Public awareness

Several studies (Le Bodo et al., 2019; Acton et al., 2022; Brukalo et al., 2022) have demonstrated that the effectiveness of SSB taxes on consumer behavior can be influenced by their perceived cost and awareness of the tax. Therefore, raising consumer awareness may be crucial to enhance public acceptance of the SSB tax and promote its potential welfare benefits. Previous research has highlighted the important of the signaling effect of tax policies, which can make consumers aware of the health implications of consuming taxed products (Barigozzi and Villeneuve, 2006; Sarda et al., 2022; Acton et al., 2022). In their study, Sarda et al. (2022) evaluate the awareness of the revised French soda tax and associated factors among 28,344 adults in mainland France who participated in the NutriNetSanté cohort study. The authors reported that 63.4% of respondents were aware of the existence of the tax, which is consistent with existing European literature (Brukalo et al., 2022). Although less than a quarter of the participants were aware of the tax design, 64.7% expressed a favorable opinion of it. As such, favorable opinions may be more prevalent if tax revenues are explicitly earmarked for health-related measures, as noted by Sarda et al. (2022).

2.1.1.4 Policy impacts

2.1.1.4.1 Impact on consumption

In the previous section, we provide evidence from the literature that the introduction of a sin good tax can rise the final price, and the magnitude of the increase depends on its design. Predicting consumer behavior in response to food taxes can be complex, and it is important to consider other factors than prices that may influence outcomes. Having a precise understanding of the product substitution that arises in response to a price variation is critical for assessing the effectiveness of the tax in achieving its objective of reducing the consumption of a specific nutrient.

Consumer demand for food is a key element for evaluating the impact of the tax on SSB consumption. Estimates of consumer demand quantify the effects of prices on the demand. These estimates, known as price elasticities, directly inform policymakers and researchers about how consumers make food purchasing decisions when facing price variations and help policymakers design effective fiscal policies. There are two types of price elasticity relevant to a sin tax: own-price elasticity and cross-price elasticity. Own-price elasticity measures the change in demand due to a change in the price of a sin good. Cross-price elasticity measures the change in demand for good *A* when the price of sin good *B* changes, leading to substitution effects across products and brands. In this case, we assume that the substitution will be toward either a non-sin good, a sin good with a lower sugar content or a cheaper sin good.[36] The impact on sugar quantities depends on both product substitutions and then on the magnitude of own- and cross-price elasticities.

Bonnet and Réquillart (2013b) conduct an estimation of the price elasticity of demand for SSB products in France. The study specifically focused on examining differentiation across various brands, beverage types and retail channels, considering a large number of products in the choice set of consumers. They employ a flexible demand model that captures both the observed and unobserved heterogeneity of consumer behavior. The findings of the study revealed that, on average, the own-price elasticity of demand for SSB products was estimated to be -3.46, ceteris paribus. These estimates confirm the existence of elastic demand for differentiated products in the SSB sector and then for large substitution effect between SSBs products. However, the French 2012 tax design (which taxed diet and regular SSBs and exempted pure fruit juices) led to a substitution towards fruit juices, which do not contain added sugar but native, thus limiting the overall reduction in sugar consumption. As both diet and regular products were taxed, this limits the substitution of regular SSB drinks to diet drinks. Moreover, the authors suggest that a flat tax without product differentiation increases the price of all sugar-sweetened beverages, leaving the relative differences between diet and regular products unchanged. On the contrary, as mentioned in the study by Ecorys (2014), retailers' brands (especially nectars) were more affected by the tax, limiting the substitution effect towards cheaper products. Bonnet and Réquillart (2013b) also concludes that the impact of the tax on the sales of retailers' brands was greater compared to the main national brands.

Globally, ex-post analyses show limited global effect on SSB consumption, revealing a small price elacticity of SSBs at the category level.

Capacci et al. (2019) evaluate the impact of this tax on purchases of SSBs using a difference-indifferences approach with two alternative control groups: two nearby regions in Italy and water. The authors estimate that, despite the price effect of the tax, the French 2012 tax reduced regular soft drink purchases by about 0.5 liters per year per capita (-2%). The authors also find some evidence of a larger response among heavy purchasers of SSBs, but no significant effects on fruit juice or water purchases. Similarly, Kurz and König (2021) conduct a comparative case study to assess the impact of two soda taxes on soda consumption: the French soda tax of 2012 and the Hungarian Public Health Product Tax (HPHP), which was implemented in 2011 and targeted beverages with sugar content above 8 grams per liter. To estimate the causal effect of the soda tax,

[36] There is another type of price elasticity: income elasticity. Income elasticity measures the effect of changes in a consumer's income on the consumption of a good.

the authors employ a synthetic control method, which involved constructing a counterfactual scenario for each country. By comparing soda purchases in these countries to a weighted average of other countries without similar taxes, they aim to identify the true effect of the tax policy.[37] Using monthly data on soda, juice, and bottled water purchases from Euromonitor International from 2008 to 2016, the authors observed a small 5% decrease (equivalent to 113 million liters) in soda consumption in France in the short term (the first year after the tax was implemented), but this effect disappeared after two years. They also show that sales of juice increased by 7.2% in the post-intervention period, suggesting some substitution effects towards other sugary drinks. However, these results remain imprecise because the confidence interval for the estimate is wide and includes zero due to the small number of observations. Consequently, the authors conclude that soda taxes may have a limited and temporary effect on soda consumption, with their effectiveness depending on the design and implementation of the tax, as well as the availability and price of alternative beverages. Finally, Chatelan et al. (2022) examine the impact of the soda tax on the frequency of soda consumption among adolescents in Europe using data from the Health Behavior in School-aged Children (HBSC) survey. They compare consumption trends between 2001-2002 and 2017-2018 in six countries that implemented or updated a soda tax, including France, with neighboring countries that did not have such a tax. Soda tax in 2012 does not lead to more favorable changes in the prevalence of daily, weekly, and occasional soda consumption in France between 2009-2010 and 2013-2014 compared to countries without a tax.

Even if the soda tax had a limited effect on consumption on average, the effect could be heterogeneous across the population. It mainly aims at reducing the consumption of high-sugar consumers, considering the potentially regressive nature of the tax and its differentiated impacts across income and age. Lower-income individuals consuming more sugar-sweetened beverages (Ntouva et al., 2013), and then have a higher risk of overweight and obesity (Botelho et al., 2019; Bruce et al., 2018), exhibit higher price elasticity estimates and larger reductions in consumption (Wang, 2015; Li and Dorfman, 2019; Etilé et al., 2021).

Potential impacts of the 2018 tax reform

Despite the absence of an assessment of the French 2018 tax design, the tax reform, due to its progressive design, could have triggered larger effects on prices, reformulation of products, purchases, and consumption, especially if demand is elastic and consumers are sensitive to price changes. Indeed, the impact of a tax reform from a flat to a progressive rate may have several implications.

First, given the higher tax rate of high sugar content products and the lower rate of low sugar content products (diet products were exempted in 2018), we expect higher

[37] The synthetic control method is a statistical technique that facilitates the estimation of the causal effect of an intervention by matching the pre-intervention characteristics and trends of the treated unit with a combination of control units.

price increase of regular SSBs and more substitution towards diet SSBs, leading to a more efficient reduction in sugar consumption. Second, the 2018 soda tax was designed as a fiscal policy aiming to change industry behaviour by bringing about reduction in the sugar content of soft drinks (Le Bodo et al., 2022). However, unlike the three-tiered taxes in the UK and Catalonia, the French tax has sixteen tiers and, on the supply side, reformulation of products could operate bunching at the thresholds, leading to small sugar content reduction. In the absence of clear target thresholds, this design can discourage any effort by companies (Le Bodo et al., 2022). However, the French tax may have different effects depending on how producers react. Some may gradually change their recipes, some may offer new products that are considered ”healthy”, and some may keep their products as they are (Chauvel, 2018; Leboulenger, 2018). The government has claimed that the tax has reduced the amount of sugar in drinks (Assemblée Nationale, 2018), and a preliminary analysis (Allais et al., 2023) confirms a 6% reduction in the sugar content of SSB products between 2017 and 2018. However, this decrease is relatively small compared to expectations, mainly due to the large number of thresholds and the overly progressive increase of the tax rate from one threshold to another. Allais et al. (2023) show that the UK tax, a three-tiered tax with a large increase in the tax rate between thresholds, was more effective in reducing the sugar content of products.

Moreover, the shift from a flat to a progressive tax rate redistributes the tax burden on individuals who consume higher amounts of sugar. This reform promotes a more equitable distribution of the tax burden and has the potential to reduce consumption inequalities. In addition, higher-sugar consumers contribute more to overall tax revenues, thereby generating additional funds for government initiatives to combat obesity and reduce the prevalence of overweight.

2.1.1.4.2 Impacts on externalities

2.1.1.4.2.1 Impacts on social and health externalities

2.1.1.4.2.1.1 Health externalities

The aforementioned studies, assessing the effect on SSB consumption, serve as the foundation for long-term health effect of soda taxes. Presently, there is a lack of assessment in France regarding the actual impact of the soda tax on health issues. Modeling studies investigating the health effects of food taxes yield inconclusive results due to uncertainties surrounding product substitution (Ecorys, 2014) and their limited influence on consumption. The relationship among alterations in nutrient intake, weight loss, and disease prevalence is intricate, and each stage in the simulation process is complex, with the credibility of the final conclusions contingent upon the quality of data and the methodological approach employed. Furthermore, the French tax has only been applied to a relatively small proportion of products containing sugar, only SSBs. Moreover, establishing a clear association between the long-term reduction in daily soda consumption and other public health nutrition measures implemented in France between 2009-2010 and 2017-2018, including mandatory nutritional standards for school meals, water promotion in 2011-2012, and the voluntary front-of-pack nutrition label known as the Nutriscore in 2016-2017, proves challenging (World Cancer Research Fund International, 2021).

Longer-term data and surveys are then needed to evaluate the impact of reduced consumption of unhealthy products on obesity and diabetes in France and other EU countries.

2.1.2 Nutrition labelling

Nutrition labelling is an important, but complex policy tool to implement WHO's recommendations (World Health Organization, 2022) and promote healthy diets (Sacks et al., 2011a; Labonté et al., 2018).

The Codex Guideline on Nutrition Labelling provides principles for additional nutrition information to support back-of-pack and front-of-pack nutrition labeling. The objective of nutrient declarations on the back of food packages is to furnish consumers with a *"suitable profile of nutrients contained in the food and considered to be a nutritional importance."* In contrast, supplementary nutrition information on the front-of-package aims to *"increase the consumer's understanding of the nutritional value of their food and to assist in interpreting the nutrient declaration"* (Codex Alimentarius Commission, 1985). In this case, nutrition labels provide consumers with accurate information on the energy and nutritional content of packaged foods (Campos et al., 2011), as defined by the FAO/WHO Codex Alimentarius (Codex Alimentarius Commission, 1985)[38], while encouraging industry to use health-promoting principles in product formulation and complementary food systems (Van den Wijngaart, 2002).

Mandatory and voluntary nutrition labeling, regardless of whether the product contains a nutrition or health claim, has become a global trend in recent years. In 2012, the Codex Alimentarius recommended mandatory nutrition labeling (or nutrient declarations). Figure 2.4 shows that mandatory and voluntary nutrition labeling, which can be back-of-pack or front-of-pack labels, has been adopted by many countries.

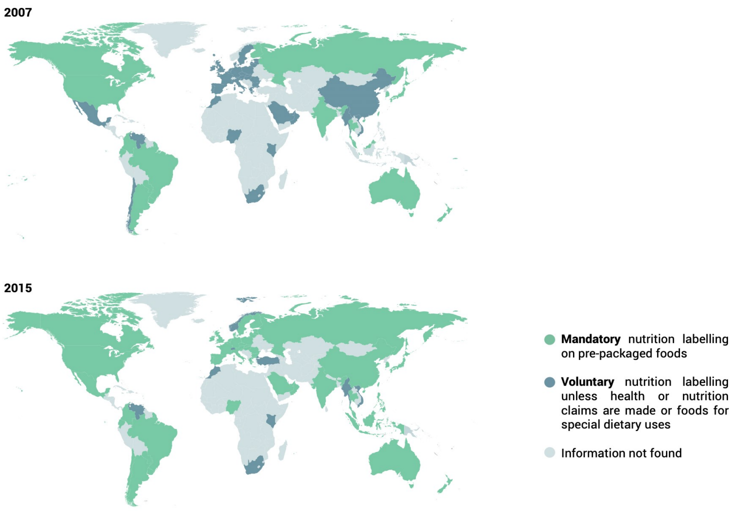

Figure 2.4: Map of Global overview of mandatory and voluntary nutrition labelling (2007 and 2015). (Source: EUFIC (2006)).

[38] The FAO/WHO Codex Alimentarius is an internationally recognized set of guidelines for nutrition labelling, with provisions for voluntary declaration, calculation and presentation of nutrition information (Codex Alimentarius Commission, 1985).

In the next section, we describe the impact of the Nutri-score, the front-of-pack warning label, that was chosen by France to inform consumers about the nutritional quality of food products.[39]

2.1.2.1 *Front-of-package warning labels*

2.1.2.1.1 Introduction

Front-of-pack labeling systems are used on the front of food packages to provide simple information, often graphic, about the nutrient content or nutritional quality of products. They appear to be a complementary information system (Egnell, 2020) when traditional back-of-pack nutrition labelling is difficult to understand and use (Thow et al., 2019). These labels are designed to help consumers understand at a glance the nutritional content and quality of the food they buy (OECD, 2008; Hercberg, 2013). They are also intended to encourage food manufacturers to improve the nutritional quality of their products.

Many countries have introduced various types of front-of-pack nutrition labeling in the recent decades. Different approaches were adopted with some focusing on individual nutrients that are associated with chronic diseases, and others focusing on the overall nutritional quality of foods. These differences in format and content have been shaped by different cultural, political and demographic contexts (Thow et al., 2019).

Logos can convey either a positive judgment, in the case of ”quality seal” logos, and/or a negative judgment, in the case of ”warning” logos. Front-of-package labels can be classified as ”nutrient-specific” or ”summary indicators”, according to the type of information they provide, as well as graphic format (Figure 2B.4):

- *Nutrient-specific schemes* provide information on nutrients in foods that are associated with a higher risk of chronic disease, including the percentage of these nutrients (e.g. salt, fat, sugar) and their compliance to the recommended daily intake. They are used in Finland, Indonesia, Chile, Argentina, and Peru. These logos come in a variety of forms, including purely numerical logos that provide information on specific unfavourable nutrients (e.g. GDAs or reference intakes), colour-coded logos that assign a colour to each nutrient level (e.g. red for high, yellow for moderate and green for low, like traffic lights), and, warning logos that appear on products when the level of a nutrient exceeds a certain threshold.
- *Summary logos* provide consumers with an overall evaluation of the food’s overall nutritional quality. There are two types of summary logos:
    - Logos that indicate the nutritional quality of the product on a graded scale (e.g. NutriScore, Health Star Rating, which have been introduced in Australia, New Zealand, France, Belgium, Spain, Germany, Switzerland, the Netherlands and Luxembourg); and

[39] This note on nutrition labelling is mainly based on Manon Egnell’s thesis on the impact of ”Nutriscore” front-of-pack nutrition labelling on consumers (Egnell, 2020).

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- logos that certify products of higher nutritional quality within a given category (e.g. Green Keyhole in Sweden, the first binary logos introduced in 1989).

2.1.2.1.2 EU Regulation

Food labeling at the EU level is regulated by the Food Information to Consumers Regulation (**EU Regulation (EC) No. 1169/2011 of October 2011 on the provision of food information to consumers**)[40], also referred to as the INCO Regulation. Since December 2016, most prepackaged foods must include a nutrition declaration on the back of their packaging to help consumers make informed food choices. The nutrition declaration should include information on the energy value, total fat, saturated fat, carbohydrates, sugars, protein, and salt content, expressed per 100 g or 100 ml (optionally per portion). However, European legislation does not harmonize the presentation of front-of-pack nutrition information. Current EU legislation allows the voluntary provision of front-of-pack nutrition information as long as it complies with EU law and cannot be made mandatory by Member States (Gokani, 2022). Alternative formats, such as graphics or symbols, may therefore be voluntarily used to communicate energy values and nutrient amounts.

Article 27(4) of Regulation (EC) No/ 1924/2006 of 20 December 2006 on nutrition and health claims made on foods[41] and the **Directive (EU) 2015/1535 of 9 September 2015 laying down a procedure for the provision of information in the field of technical regulations and of rules on Information Society services (codification)**, known as the ”Transparency” Directive[42], complement this regulatory framework. Article 27(4) limits nutrition claims in the form of pictures, symbols or graphics to a positive list drawn up at the time of the adoption of the Regulation. To add a new claim to the list, the competent authority of the Member State concerned must notify the European Commission and a six-month standstill period must be observed.

2.1.2.1.3 Nutri-score system

Nutri-Score is a simple, understandable rating system for the overall nutritional value of food. NutriScore is originally calculated as a numerical value (a score) which is then converted to into five color-coded categories (Chantal et al., 2017).[43] Figure 2.5 shows a graphical overview of how the Nutri-Score is calculated.

The algorithm employs a points-based approach to assign foods and beverages a category. The nutrient profile is based on the nutrient content per 100g of the food or beverage. There are nutrients that should be reduced (energy, sugar, saturated fat, and sodium) and others increased (fruit, vegetable, nut, fiber, and protein contents. A Food

[40] Sources: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32011R1169&from=FR
[41] Sources: http://data.europa.eu/eli/reg/2006/1924/oj
[42] Sources https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32015L1535&from=FR
[43] This labelling system is derived from the Food Standards Agency Nutrient Profiling System (FSAm-NPS), which was originally developed by an Oxford research team for OfCom, the UK media regulator, to regulate television advertising to children. The French High Council of Public Health (HCSP) adapted and modified the FSAm-NPS to adapt it to the French context and to suit its application to a five-level nutrition labeling system (Rayner et al., 2004).

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Standards Agency Nutrient Profiling System (FSAm-NPS) score is evaluated on a discrete continuous scale from -15 (healthiest) to +40 (least healthy). Five categories are considered and are labeled by color and letter which are displayed on the packaging of products.

Front-of-pack labels were first proposed in France in 2013, as part of the PNNS 2011-2015[44], and followed by a four-year consultation process with multiple stakeholders and industry lobbying (Julia and Hercberg, 2018).[45] A large-scale experiment was then conducted on behalf of the French Ministry of Health to compare the effectiveness of four labeling systems, including the Nutri-Score, SENS, Nutri-Repère, and Nutri-Couleurs (Figure 2B.5). The experiment, conducted over a 10-week period in 60 French supermarkets, revealed that the Nutri-score system was the most effective in encouraging consumers to make healthier food choices. In contrast, the other labeling systems received criticism from consumers and experts due to their complexity and lack of transparency.

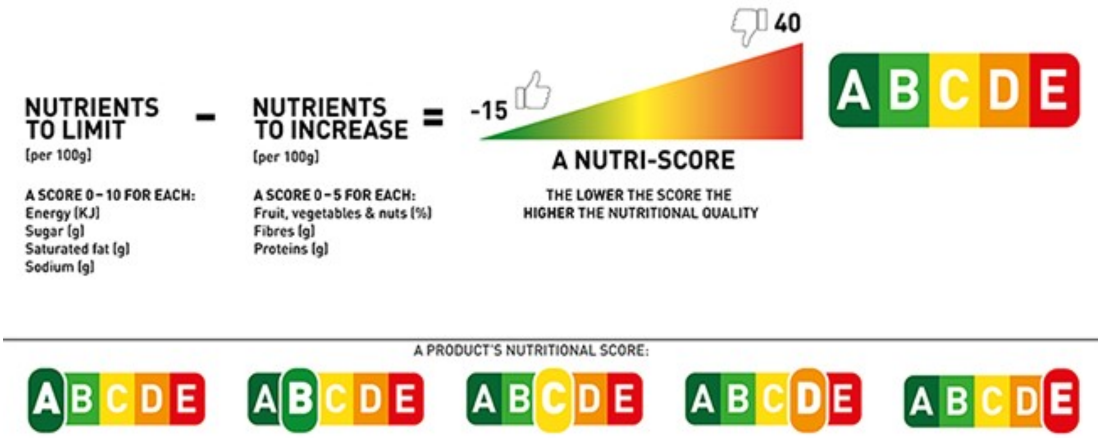

Figure 2.5: Nutriscore notations

(Source: https://get.apicbase.com/fr/nutriscore-systeme-etiquetagevaleur-nutritionnelle/)

The Nutri-Score label was adopted on a voluntary basis on October 31st, 2017 (Julia and Hercberg, 2018) in accordance with Decree No. 2016-980. This decree outlines guidelines for providing supplementary nutrition information on food products, including specifications for the logo design and compliance with the provisions of the INCO Regulation.

[44] Serge Herberg (2013), "Propositions pour un nouvel élan de la politique nutritionnelle française de santé publique", ("Proposals for a new impetus for French public health nutrition policy), report to the French Minister of Health. Access here: https://sante.gouv.fr/ministere/documentation-et-publicationsofficielles/rapports/sante/article/propositions-pour-un-nouvel-elan-de-la-politique-nutritionnelle-de-sante (in French)

[45] The proposed system aims to enable consumers to quickly and comprehensively understand the overall nutritional quality of food, and to encourage distributors and agri-food manufacturers to improve the nutritional quality of their products through reformulation and innovation.

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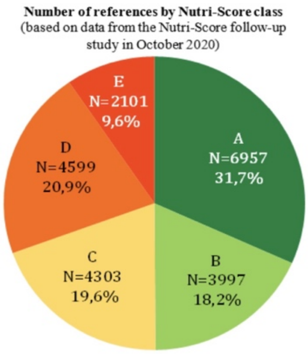
Santé Publice France, as the rights holder, mandates that food manufacturers desiring to utilize Nutri-Score on their products must register its use and apply Nutri-Score to all their products within a two-year timeframe.[46] As of June 2022, 989 companies have committed to the Nutri-Score approach in France. Since 2018, the estimated market share of committed brands has grown steadily, reaching 58% of sales volume in 2022, broken down into 30% for private labels, 20% for national brands, and 8% for other market segments.[47] The 2020 Nutri-Score Follow-Up Report, conducted by the Observatory of Food Supply (Oqali), provides descriptive evidence on market share and structure of the use of the label. The report uses data from 226 out of 398 registered food companies, covering the period between October 31, 2017 and June 2, 2020. It includes an analysis of 24,553 food products in 2020 (Oqali, 2020; Santé Publique France, 2021). The implementation of Nutri-Score in France has led to an increase in the number of participating brands, including multinational companies, in different market segments of supermarkets and similar retail outlets. Figure 2.6 displays the distribution of food products by Nutri-Score classes on the French market. Figure 6a shows that the most common Nutri-Score class was A (31.7%) and the least common was E (9.6%). National brands used the Nutri-Score primarily on packaging, while retailer brands used it on both packaging and e-commerce for products sold in supermarkets and similar retail outlets. The distribution of products by Nutri-Score class is consistent across specialized retailers, hard discount, and retailers (Figure 6b), with 23-27% of products classified as A, 14-21% as B, 21-27% as C, 18-27% as D, and 5-15% as E. However, national brands have a different distribution (Figure 6c), with a higher proportion of products classified as A (48%), and a significantly lower proportion of products classified as E (1%). Retailers are required to use the Nutri-Score on all references from all food categories, resulting in a more even distribution of the different Nutri-Score classes compared to national brands. The coverage of engaged brands displaying Nutri-Score grew steadily from 2018 to 2020. This growth was primarily driven by retailer brands and national brands.

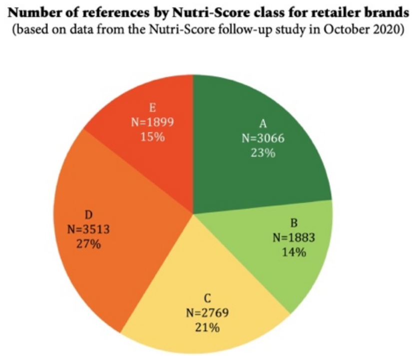
Several European countries, such as Spain in 2018, Belgium in 2019, and Germany in 2020, have followed France's approach and implemented the Nutri-Score label. The Nutri-Score label is currently trademarked across the European Union.

[46] Santé Publice France, Conditions of the Use of the « Nutri-Score » Logo, January 2022, https://www.santepubliquefrance.fr/media/files/02-determinants-de-sante/nutrition-et-activite-physique/nutriscore/reglement-usage-en

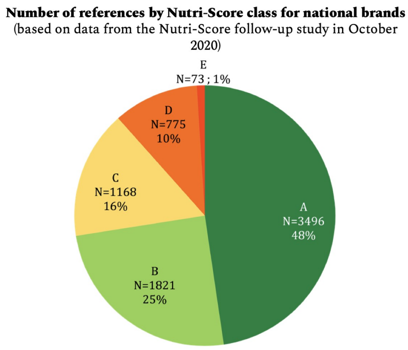
[47] According to Oqali (June 2022), https://www.oqali.fr/media/2023/04/OQALI-2022_Suivi-du-Nutri-Score.pdf



(a) Distribution of products sold



(b) Distribution of products from retailer in supermarkets and similar retail brands by Nutri-Score class (N=13,130) outlets by Nutri-Score class



(c) Distribution of products from national brands by Nutri-Score class (N=7,333)

Figure 2.6: Nutri-Score and its distribution in the French food market (Source: Oqali, 2020; Santé Publique France, 2021)

2.1.2.1.4 Mechanisms of the instrument for internalization

Figure 2.7 illustrates the effect pathways from implementation of the Nutri-Score to changes in health externalities. In this section, we describe the three underlying mechanisms of the Nutri Score labelling system that may impact healthier diets and subsequent health outcomes. First, we present the effect on product reformulation and innovation. Second, we discuss how the labelling system may introduce some vertical differentiation between products and then affect market prices. Third, we describe how the Nutri Score could improve public awareness of healthier eating behaviors.

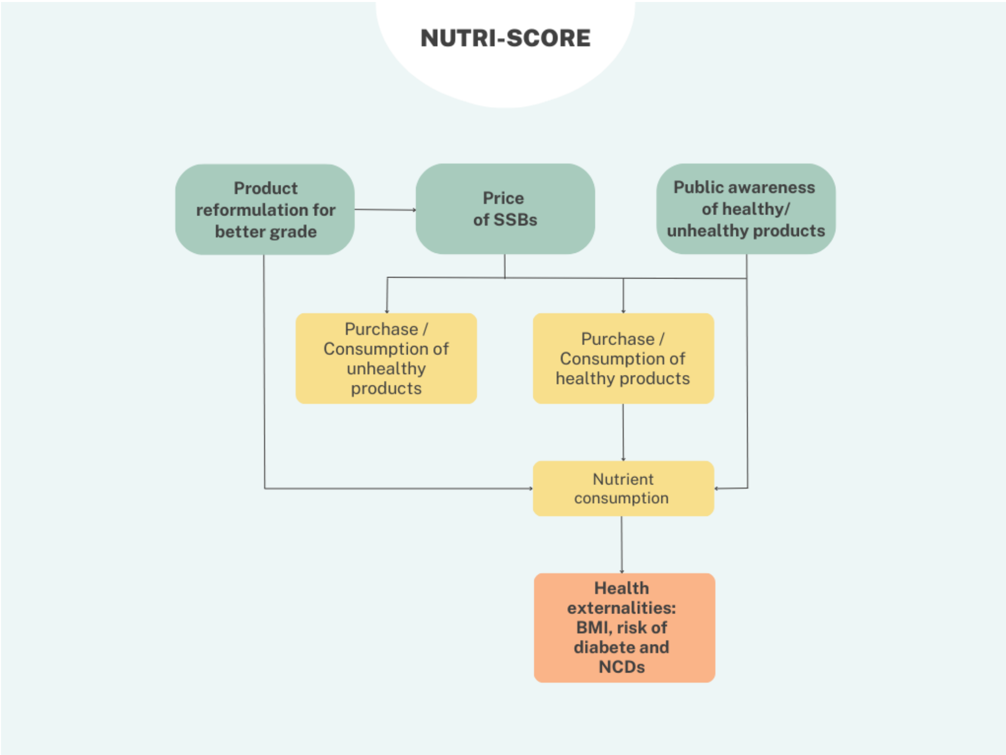


Figure 2.7: Pathways of Effects

2.1.2.1.4.1 Product reformulation and innovation

The available data suggest that front-of-package nutrition labeling may have a positive influence on the reformulation of existing foods, resulting in a healthier food supply characterized by improved nutrient content and subsequent improved nutritional scores, particularly with respect to nutrients such as sugars and sodium (Vyth et al., 2010; van der Bend et al., 2020).[48] According to ter Borg et al. (2021), reductions in sodium, saturated fat, and sugars led to a more favorable Nutri-Score in numerous food groups.

The French consumer association, UFC-Que Choisir, conducted a study to evaluate the efficiency of voluntary Nutri-Score displaid by specific food industry stakeholders in improving the nutritional quality of food products in France (UFC-Que Choisir, 2023). In the absence of a publicly available database on food nutritional quality, UFC-Que Choisir performed a comparative analysis of Nutri-Score distribution between 2015 and 2022 across seven product families that met specific criteria, including consistent product identification, potential for nutritional improvement, and high proportions of 'E' and 'D' Nutri-Score ratings. The study identified significant improvements in three categories,

[48] Breton et al. (2019) also show that the Nutri-Score can trigger different drivers of corporate practice, with small and medium-sized food manufacturers more likely to welcome it as a means of differentiating themselves from multinationals.

namely breaded products, cereal bars, and breakfast cereals, with a modest improvement in four others, namely industrial cookies and cakes, chocolate products, condiment sauces, and ice cream/sorbets. Regarding cereal bars, similar nutritional improvements by 2020 primarily included reductions in saturated fat (-13% on average) and sugar (-8%), with modest reductions in salt (-5%) and increases in fiber (+5%). In breakfast cereals, saturated fat was reduced by 34% on average, salt by 24%, and sugar by a modest 6%. Based on the above descriptive analysis, the study concludes that the voluntary nature of the Nutri-Score label limits its impact on improving the nutritional quality of food. This is why the French government is promoting legislation for mandatory front-of-pack labeling throughout the European Union, particularly to promote the Nutri-score.

2.1.2.1.4.2 Impact on prices

Although limited knowledge exists regarding the influence of Nutri-Score on market prices (Pachali et al., 2023), previous theoretical and empirical research has emphasized the strategic responses of firms to summary logos other than Nutri-Score (such as the Health Star Rating System) and warning systems, including their use of price adjustments (Villas-Boas et al., 2020).

In their study, de Abreu et al. (2019) investigates the potential price differences between healthier products and less healthy alternatives, specifically focusing on the HSR system, on a sample of 1,578 participants in Australia from June 2014 to September 2016. They specifically analyze three product categories: breakfast cereals, cereal-based bars, and fruit juices. On average, the findings reveal no significant correlations between the HSR and the prices based on energy and unit. However, small positive associations are observed for juice and cereal-based bars, indicating some potential pricing differences in these categories.

Moreover, warning label systems are unique in that they highlight the negative aspects of a product's nutritional composition. In response to the Chilean Food Act of 2016, Barahona et al. (2023) find that warning labels led to supply side effects, including firm's price adjustments and product reformulations.

Firms may choose to incorporate healthier ingredients and reduce sugar and calorie levels to circumvent the warning label requirement, thereby increasing the positive impact on dietary intake. However, this practice also results in higher consumer prices due to increased production costs. The study provides evidence of a 5.5% increase in the price of unlabeled products relative to labeled products as a direct result of the regulatory measures.

According to Velasco Vizcaíno and Velasco (2019), front-of-pack nutrition labels may create a double burden for small food manufacturers, hindering competition and taking up space on the packaging, leading to increases in prices and shopping costs. In their study, Pachali et al. (2023) examine the equilibrium price changes in response to consumer utility following the mandatory introduction of warning labels in Chile. The analysis utilizes household purchase data in the cereal category. The results show a desirable unintended consequence of the labeling regulation, where labeled (”bad”) cereals experience higher prices, and unlabeled (healthiest) products experience price decreases or limited price increases. According to the authors, this price adjustment is attributed to a *composition effect* in which more price-sensitive consumers shift their preferences towards unlabeled products.

Further research is needed to explore the adoption patterns of front-of-pack labeling systems by manufacturers, the key characteristics that influence their decisions, and the relationship between front-of-pack nutrition labeling and pricing, especially in the case of Nutri-Score. In fact, it is crucial to evaluate the cost-effectiveness of front-of-pack nutrition labeling.

2.1.2.1.4.3 Public awareness

Front-of-package nutrition systems, including Nutri-Score system, are commonly employed by policymakers to enhance the salience of nutritional information for consumers regarding their product choices, compared to back-of-pack labels (Becker et al., 2016; Graham et al., 2015; Egnell, 2020). In France, the Nutri-Score system has gained significant awareness among consumers, with a majority supporting its implementation and considering it as a valuable tool for evaluating nutritional value (Santé Publique France, 2021).

Attention to specific attributes influences consumer sensitivity to other product attributes, and Nutri-Score enhances the positive impact of healthier nutrient profiles on purchase intention (Gassler et al., 2023; Grunert et al., 2010). Logo understanding and preferences also vary by socio-demographic characteristics such as nationality, gender, education level, age, and BMI. Some logos may be well perceived but poorly understood (Malam et al., 2009; Campos et al., 2011; Grunert and Wills, 2007). Factors such as visual appeal, ease of understanding, and quick interpretation of logos play a significant role in improving food choices (Kim and Kim, 2009; Malam et al., 2009). Logo size (Bialkova and van Trijp, 2010; Bialkova et al., 2013; Bommer, 2019), color (Bialkova and van Trijp, 2010; Bialkova et al., 2013) and location (Bialkova and van Trijp, 2010; Bialkova et al., 2013; Bommer, 2019) are found to influence attention. In particular, the use of colors has been found to guide consumers towards healthier products, with reds activating an area involved in self-control and greens activating an area involved in the attribution of value (Arrúa et al., 2017b; Crosetto et al., 2016, 2020).

In a cross-national study by Talati et al. (2019), different front-of-pack labels, including NutriScore, are evaluated in terms of consumer perceptions and acceptability, measured on a scale from ”strongly disagree” to ”strongly agree” regarding liking, trust, comprehensibility, salience and desire to make the label mandatory. The study revealed that color-coded logos, particularly the multiple traffic light label, received the highest acceptability scores, while perceptions of Nutri-Score and other labels were mixed or neutral. Moreover, oversimplification of information can undermine consumer confidence and result in resistance in making choices they do not instantaneously desire (Grunert and Wills, 2007). A descriptive analysis conducted by E.Leclerc, 2018 show that the

Nutri-Score improved consumers' perception of the nutritional quality of their own-brand products, compared to the Health Star Rating or the absence of any label.

Dubois et al. (2021) conduct a large-scale trial to examine the impact of front-of-pack nutrition labels on food purchases in a real-life setting. The authors use the nutritional quality of 1,668,301 purchases made in 60 supermarkets. The products in these supermarkets were labeled with different types of FOP labels, including no label (20 supermarkets), SENS nutrition label, Nutri-Score, NutriRepère, or Nutricouleur. To assess the effectiveness of the labels in capturing attention and perceptions of healthfulness, shoppers were surveyed before and during the labeling phase. The results show that the Nutri-Score and SENS labels attracted similar attention and significantly more attention than the Nutri Repère and Nutricouleur labels. In a longitudinal study involving 4,006 French adults conducted by Sarda et al. (2022), data was collected across three waves from April 2018 to May 2019. An online survey was used to examine Nutri-Score awareness, support for the intervention, and subsequent behavioral changes. The findings reveal a significant and gradual enhancement in logo awareness among participants following the implementation of a national communication campaign, with an initial increase of 17.2% points and a subsequent increase of 6.1% points.

2.1.2.1.5 Policy impacts

2.1.2.1.5.1 Impact on consumption

Research has examined the impact of Nutri-Score labeling on consumer purchasing behavior, including both experimental and real-world situations (Grunert et al., 2010; Khandpur et al., 2018; Crosetto et al., 2016, 2020; Ducrot et al., 2016; Julia et al., 2016; Ruffieux et al., 2011; Franco-Arellano et al., 2020; Dubois et al., 2021). The labeling system has demonstrated its effectiveness in facilitating consumers' improved assessment of the healthiness of products (De Temmerman et al., 2021), and consequently in reducing the purchase of unhealthy foods and beverages while promoting the purchase of healthier alternatives (Egnell et al., 2021; van den Akker et al., 2022, see for other European countries (Ares et al., 2018; Khandpur et al., 2018; Acton et al., 2018)). In France, Nutri-Score has demonstrated a significant impact on consumer purchasing behavior, with up to 57% of respondents indicating that they have changed at least one purchasing habit as a result of Nutri-Score in 2020, compared to 43% in 2019 (Sant´e Publique France, 2021). However, some other studies mitigate the results on the effect of front-of-pack nutrition systems on purchases (Graham et al., 2017; Sacks et al., 2009). These results may stem from consumers not fully understanding front-of-pack labels, or from limited use of these labels across different products.

Julia et al. (2016) conduct an evaluation of the potential influence of the 5-CNL, the first version of the Nutri-Score, on the dietary patterns of adults in France. The authors also conclude that the 5-CNL has a slight effect on purchasing behavior within certain food categories, such as sweet biscuits.

Nutri-Score has been shown to be an effective tool in public health nutrition (Julia et al., 2016; Chantal et al., 2017; Julia and Hercberg, 2018) and more effective than comparable labels (such as Traffic Light labelling) at improving diet quality (Ducrot et al., 2016). Dubois et al. (2021) also find that the Nutri-Score label outperformed four other nutrition systems, leading to a 14% increase in purchases of foods with the highest nutritional value. Based on their findings, Dubois et al. (2021) conclude however that front-of-package nutrition labels have a limited but positive effect on the nutritional quality of food purchased under real-life shopping conditions, across all income subgroups of the population.

2.1.2.1.5.2 Impacts on externalities

2.1.2.1.5.2.1 Impacts on social and health externalities

2.1.2.1.5.2.1.1 Health externalities

From a public health policy perspective, an ideal front-of-pack nutrition label would lead to healthy dietary changes with minimal adjustment costs (Crosetto et al., 2020). Based on the observed effects of the Nutriscore on purchases in a laboratory experiment, the Nutriscore could reduce deaths from chronic diseases, particularly cardiovascular disease and cancer, by improving dietary intake (Crosetto et al., 2020). In a recent study, Egnell et al. (2019) examine the potential impact of five front-of-package nutrition labels, namely the Nutri-Score label system, the Health Star Rating System, Multiple Traffic Lights, Reference Intakes, and SENS, in reducing mortality associated with non-communicable chronic diseases. A macro-simulation study using the PRIME model shows that the Nutriscore was the most efficient of the five formats tested, leading to a substantial reduction in chronic disease mortality (3.4%). However, since the overall analysis in real life conditions shows very small effect of Nutri-Score on the nutritional quality of purchases (17 times smaller than those found in the laboratory study; see Crosetto et al. (2020); Dubois et al. (2021)), expected real health effects are smaller.

2.1.2.1.6 Discussion on other front-of-pack label systems

2.1.2.1.6.1 Mechanisms of other front-of-package nutrition labels

2.1.2.1.6.1.1 Impact on consumer attention, awareness and understanding

Front-of-pack label systems that are attention-grabbing and facilitate easy information processing are preferred over those requiring more cognitive effort. Nutrient-specific warning labels and summary indicators such Nutri-Score may be more efficient in terms of reading speed and improving consumer understanding of excessive nutrient content (Arrúa et al. (2017b).[49] Color-coded traffic light systems are indeed preferred over monochrome logos due to their ease of understanding (Becker et al., 2016; Antúnez et

[49] See Arrúa et al. (2017b); Goodman et al. (2018); Deliza et al. (2020); Ares et al. (2018); Julia et al. (2017); Ducrot et al. (2015); Talati et al. (2016)

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al., 2013; Malam et al., 2009), and symbols, signals, and descriptors such as ”high” or ”low” are associated with positive attitudes toward logos as they are easily identifiable and comprehensible (Arrúa et al., 2017b). In particular, interpretative labels, such as *Traffic Light labels*, have been found useful and informative by consumers in Ecuador and the UK (Freire et al., 2017; UK). In Australia and New-Zealand, the *Health Star rating (HSR) system* has garnered positive reception, as consumers have reported a favorable attitude towards it, indicating understanding and active utilization (Jones et al., 2019). For instance, *Chile’s warning label* has reduced the ”health halo” effect and improved nutrition knowledge among mothers of pre-school children (Correa et al., 2019; Mediano Stoltze et al., 2021). In Mexico and Uruguay, warning labels have gained high approval and usage, helping consumers identify products with excessive sugar, fat, saturated fat, and sodium content (Ares et al., 2012; Alianza por la Salud Alimentaria, 2021). On the other hand, *Guideline Daily Amounts labels* are not helpful, particularly for groups with low levels of food and nutrition literacy, and are the most confusing, take the most time for shoppers to evaluate, and are ultimately the least effective for encouraging consumers to make healthier choices (Julia et al., 2017; Neal et al., 2017; Jáuregui et al., 2020).

2.1.2.1.6.1.2 Impact on reformulation and innovation

Outside France, van der Bend et al. (2020) conduct a study that examine the influence of criteria revisions on the nutrient content of 4,343 products with the *Dutch Choices logo* across 27 basic and non-basic product categories from 2006 to 2016. The authors find that the Dutch Choices logo can facilitate reformulation towards healthier products by establishing nutrient criteria that products must meet to receive the label. The extent of reformulation varied across product categories and nutrients. Sodium and trans-fat were significantly reduced in 10 and 11 product categories, respectively, while energy, saturated fat, and added sugars were significantly reduced, and fiber was increased in 4-6 product categories. Moreover, studies by Ni Mhurchu et al. (2017) and Bablani et al. (2021) conducted in New Zealand and Australia reveal that the voluntary *HSR system* led to significant reformulation in certain products, as compared to non-HSR-labelled products. However, recent estimates suggest that the impact of reformulation in Australia and New Zealand is modest, primarily due to the higher adoption of the label by healthier products rather than unhealthy ones (Bablani et al., 2021).

2.1.2.1.6.2 Policy impacts

2.1.2.1.6.2.1 Impact on healthiness of consumer purchases and diet quality

The literature on food-of-pack labelling policies suggests that color-coded summary indicators like Nutri-Score may be more effective in encouraging the purchase of healthier products, while warning labels are more effective in discouraging unhealthy purchasing behavior.

A 2021 meta-analysis of over 100 studies found that the *Multiple Traffic Light system*, nutrient specific warning logos, and Nutri-Score systems increased the selection of healthier products and decreased the selection of less healthy products (Song et al., 2021; Egnell, 2020). However, it is important to note that this finding should be interpreted cautiously, as mixed results have been reported in the literature. For example, a short-term study conducted on a limited sample of ready meals and sandwiches found no significant effect of Multiple Traffic Light labels on the relative healthiness of consumer purchases (Sacks et al., 2009). The effects of the *HSR system* on purchasing are also largely unknown (Jones et al., 2019). In Uruguay, warning labels on snack foods had a stronger impact on children's food choices than traffic light labels (Arrúa et al., 2017a). They outperformed GDA-style labels or no labels in attracting adult shoppers' attention and discouraging the selection of labeled products (Machın et al., 2019). Focus groups with low- and middle-income mothers in Chile also revealed changes in food purchasing attitudes influenced by knowledge gained from warning labels and the persuasive influence of children who discourage their mothers from buying labeled products (Correa et al., 2019; Corvalán et al., 2019; Barahona et al., 2023).

In another meta-analysis, Croker et al. (2020) also indicate that these aforementioned labelling systems are linked to reduced energy, sodium, and total saturated fat content in purchases. Specifically, front-of-pack label policies can potentially reduce total energy intake by 6% to 13%, depending on its design (Smith Taillie et al., 2021). Chile presents compelling evidence that nutrient-specific warning labels lead to substantial reductions in real-world purchases of targeted unhealthy products (Song et al., 2021). This effect is observed following a robust legal mandate that incentivized the food industry to reformulate their products, thereby promoting the production of healthier alternatives (Reyes et al., 2020; Quintiliano Scarpelli et al., 2020). Emerging evidence from Mexico also indicates that the warning label system encourages reductions in nutrients of concern, such as sugar, salt, and saturated fat (Alianza por la Salud Alimentaria, 2021).

2.1.2.1.6.3 Impacts on externalities

2.1.2.1.6.3.1 Impacts on social and health externalities

2.1.2.1.6.3.1.1 Health externalities

Grummon et al. (2019) aims to assess the potential impact of implementing health warnings on SSBs in the United States. Using a stochastic microsimulation model, the authors show that these dietary changes would result in a 0.64 kg/m^2 reduction in average BMI and a 3.1%-point reduction in obesity prevalence, as well as NCDs 5% among US adults over five years. In addition, the study highlights the additional benefits of warning policies in reducing sociodemographic disparities in SSB consumption and obesity outcomes, particularly among black and Hispanic adults and those with lower socioeconomic status. Overall, these findings suggest that the implementation of health warnings on SSBs holds promise for positively influencing population-level dietary behaviors and improving health outcomes.

2.1.2.1.6.3.1.2 Impacts on economic externalities

Any costs associated with front-of-pack label policies are likely to be offset by savings in healthcare costs associated with a shift towards consuming healthier diets or through product reformulation (PricewaterhouseCoopers, 2014; Sacks et al., 2011b; Mantilla Herrera et al., 2018). Comparing the cost-effectiveness of two commonly proposed policy-based interventions, namely the front-of-pack *Traffic Light nutrition labelling* and a tax on unhealthy foods, Sacks et al. (2011b) find that these interventions would both yield cost-saving benefits in preventing obesity. In Australia, according to Mantilla Herrera et al. (2018), the cost-effectiveness analysis of the *HSR system*, based on the assessment of changes in product reformulation, demonstrates its favorable cost-effectiveness compared to a willingness-to-pay threshold of A$50,000 (equivalent to €30,526) per Healthy Life Year (HALY). This finding implies that the implementation of the Health Star Rating system is justified from an economic standpoint, as it yields positive health outcomes in relation to its associated costs.

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Appendix 2A Additional Tables

Table 2A.1: List of SSBs concerned by the soda tax in France

Beverages concerned	Beverages not concerned
Fees apply to the following beverages: • Packaged in a container intended for retail sale (*e.g.* bottle, keg, barrel, can, jar) • Falling within CN codes 2009 (fruit or vegetable juices) and 2202 (mineral and aerated waters containing added sugar or other sweetening matter) of the Customs Tariff • Sold in France directly to the consumer or through a professional (*e.g.* restaurant, liquor store) *The contributions on sweetened drinks concern drinks and liquid preparations for non-alcoholic drinks:* • Containing added sugar, whatever the quantity (*e.g.* fruit or vegetable juices, lemonades, flavored waters) • Containing synthetic sweeteners in any amount (*e.g.* diet drinks) without added sugar • With an alcohol content not exceeding 1.2% by volume, or 0.5% for non-alcoholic beers or mixed drinks • If the product contains both added sugars and sweeteners, the sale is subject to both taxes	• Milk-based beverages (infant or growing milks, drinking yogurts) • Soups or broths • Medically prescribed beverages (as part of a special diet) • Soy-based beverages with at least 2.9% protein from soybeans • Enteral nutrition products for the sick • Beverages prepared and delivered in unopened cups from vending machines • Tea- or coffee-based beverages when consumed in containers (*e.g.* cup, glass, bowl, sealed mug) intended for consumption on the premises of a restaurant or beverage establishment • Beverages supplied on board by shipping companies or airlines (duty-free purchases) • Beverages and preparations directly exported or dispatched by the person liable for payment of the tax • Beverages and preparations supplied in France and then exported by a person not liable for tax (duty-free purchase)

Source: The French government's official administrative information site for businesses [Access on March 27, 2023].

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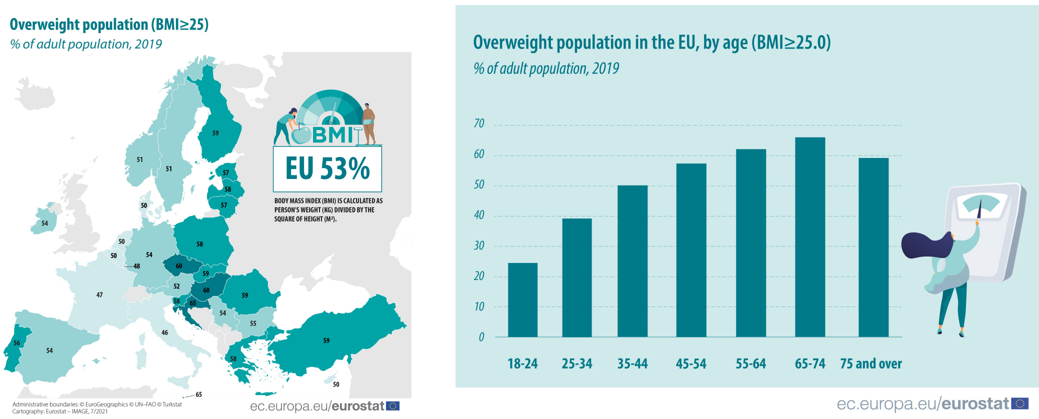
Appendix 2B Additional Figures



(a) Overweight population.

(b) BMI by age group

Figure 2B.1: Overweight and obesity in the EU: BMI Statistics

Notes: Figure 2B.1 presents statistics on the proportion of the overweight or obese population across EU countries as well as in Norway, Serbia and Turkey. The highest proportions of women considered to be obese were recorded in Estonia (23.6 %) Latvia (25.7 %), Ireland (26.0 %) and Malta (26.7 %), while for obese men the highest shares were found in Croatia (23.7 %), Ireland (25.7 %), Hungary (25.8 %) and Malta (30.6 %) (Figure 2B.1a). The age group 18 to 24 years presented the lowest shares of overweight population in the EU in 2019, while those aged 65 to 74 had the highest shares (Figure 2B.1b). Source: Eurostat, 2019.

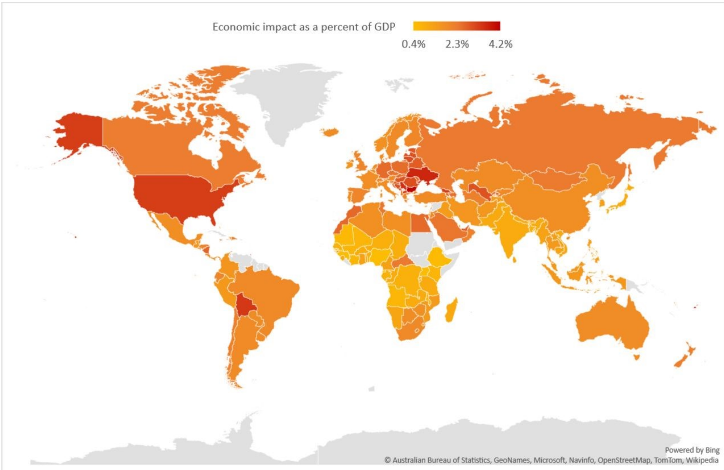


Figure 2B.2: Economic impacts of overweight and obesity per capita in 2019

Notes: Figure 2B.2 displays the economic impacts of overweight and obesity (OAO) per capita in 2019 (in 2019 USD). Data is displayed in map scaled using natural logarithm. Source: Okunogbe et al. (2022).

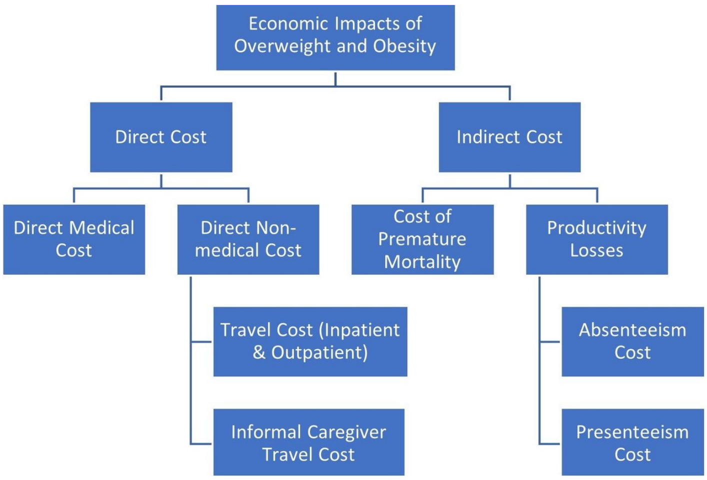


Figure 2B.3: Cost components Framework

(Source: Okunogbe et al., 2022)

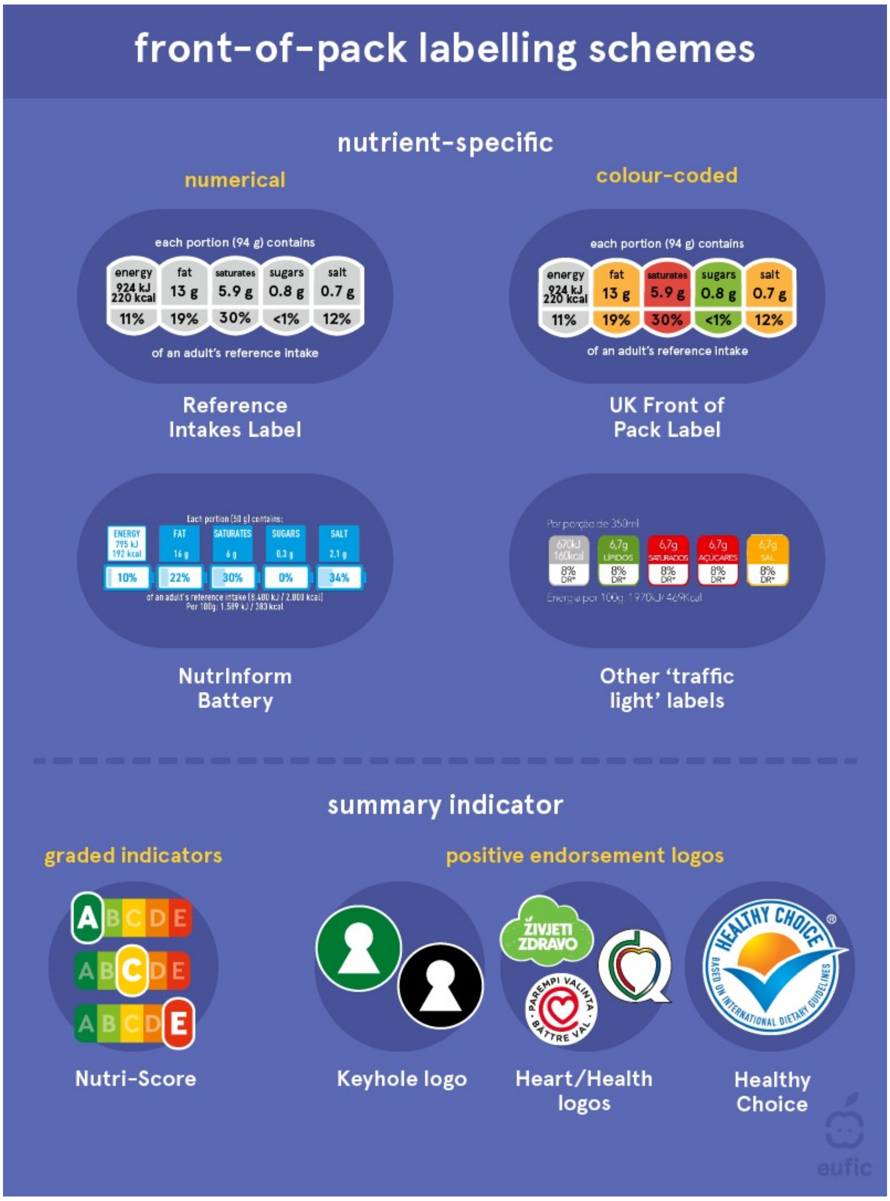


Figure 2B.4: Different FOP nutrition schemes used in different European countries.[50]

[50] *Source: https://www.eufic.org/en/healthy-living/article/front-of-pack-nutritionlabelling::text=The%20label%20shows%20how%20much,of%20the%20daily%20reference%20intake.*

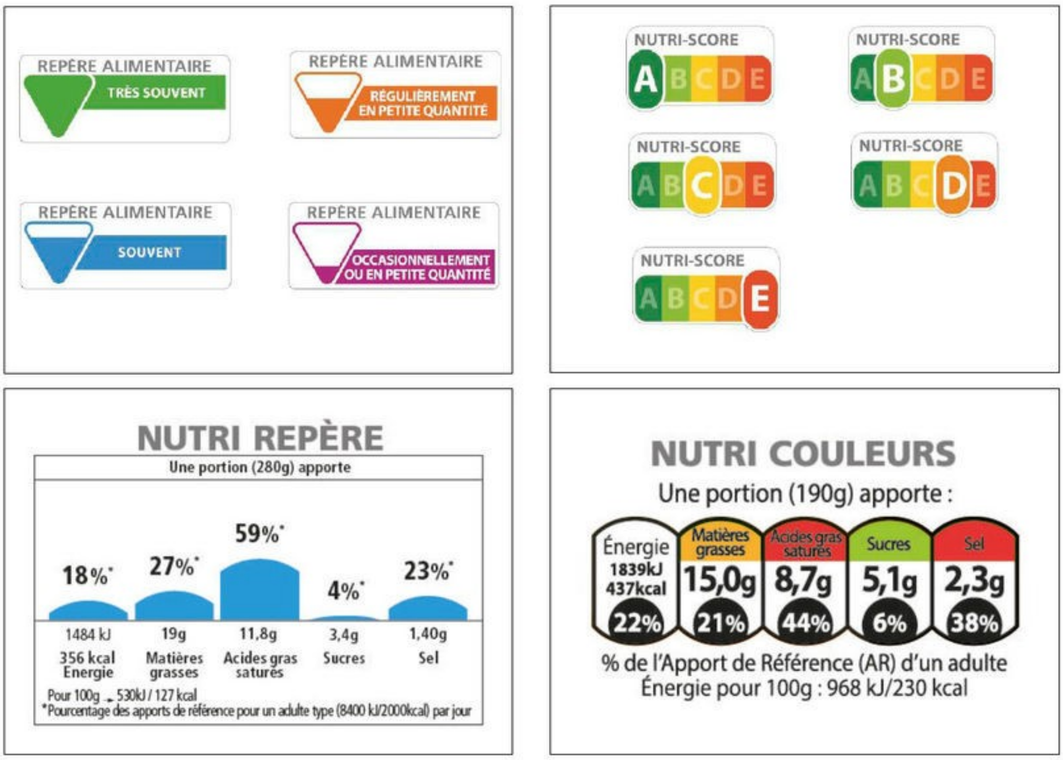


Figure 2B.5: The four nutritional labelling systems tested in France in 2013

Notes: Figure 2B.5 displays the different labelling systems that were tested in France, including two synthetic ones: (1) the Nutri-score system; (2) Simplified Nutritional Labeling Score (Score d'étiquetage nutritionnel simplifié, SENS). The SENS system is a four-color system proposed by supermarkets that includes an indication of recommended consumption frequency, based on a classification of the product's major nutrient content. Two other systems are more "analytical": (3) the "Nutri Repère", which is a system that improves on the already existing daily nutritional benchmarks. It shows the contribution in percentage and absolute value of a portion of food to the nutritional reference intakes for energy, fat, saturated fatty acids, sugars and salt; and (4) the "Traffic Lights" or "Nutri couleurs" system. Already launched in the UK, this system indicates the percentage and absolute value contribution of a portion of food to the nutritional reference intakes (energy, sugar, salt, fat and saturated fatty acids), associated with three colors (green, orange and red).

3 Natural resource and ecosystem management

3.1 Fishery and aquaculture

Key findings

- Marine ecosystems face many threats, including overfishing, pollution, and climate change. The FAO estimates that about one-third of the world's fish stocks are overfished, creating an urgent need for sustainable practices.

- Sustainable fishing practices and policy tools such as catch limits, selective fishing gear, habitat conservation, marine protected areas, and seafood ecolabels such as the Marine Stewardship Council (MSC) and the French Pêche Durable label are essential to addressing these issues.

- The French government introduced its own public ecolabel, *Pêche Durable*, in 2017 to promote sustainable fishing practices. Backed by a rigorous certification process, the label covers all aspects of the fishing industry, from production to marketing, and includes provisions to maintain the health of marine species, ensure fair working conditions, and achieve a good environmental status.

- Seafood ecolabels can impose cost burdens on fisheries due to certification requirements. Vertically differentiation of seafood products in the market often leads to higher prices for certified products. In addition, these labels raise public awareness of sustainable fishing practices and influence consumer choices toward more sustainable seafood, despite the potential "ethical confusion" caused by a proliferation of labels.

- French consumers prefer eco-labeled seafood and are willing to pay more for them, potentially promoting sustainable fishing practices. The ***Pêche Durable*** label aims to minimize environmental impacts, encourage fair labor practices, and enhance food safety. However, while eco-labeling can foster market growth and incentivize innovation, small fisheries may struggle with the cost of certification.

The marine ecosystem is a complex web of life that includes diverse species, habitats, and environmental dynamics. From microscopic plankton to giant blue whales, each entity plays a unique role in the health and vitality of our oceans. Central to these ecosystems are fisheries, which are large concentrations of a particular aquatic species that humans harvest for commercial, recreational, or subsistence purposes. Fishery stocks vary widely and include not only finfish, but also crustaceans, mollusks, and other marine life. In recent decades, however, our oceans have come under unprecedented pressure. Threats to marine life in the oceans come in many forms, including overfishing, and harvesting, waste dumping, pollution, invasive species, land reclamation, dredging, and global climate change (Beatley, 1991, Derraik, 2002). The Food and Agriculture Organization (FAO) estimates that about one-third of the world's assessed fisheries are currently overfished, indicating an urgent need for sustainable practices.

Since the 1970s, overfishing, symbolized by the "predatory fisherman" (Deldrève, 2015), has emerged as a public concern due to the degradation of marine ecosystems. Today, the focus has expanded to include food-related issues surrounding the exploitation of marine resources (Rieu, 2020). This broader issue intersects environmental, health, and socioeconomic domains. It includes issues such as seabed degradation, unintentional catch and discarding of juveniles, pollution from fish production, dioxin contamination of fish, loss of freshness, deteriorating working conditions, increasing social inequality, and economic crisis in the sector (Jackson et al., 2001; Pauly et al., 2005; Cury and Pauly, 2013). According to Worm et al. (2006), if current overfishing trends continue, all commercially exploited fish and shellfish stocks could collapse by 2048. However, it is important to remember that seafood (regardless of its level of sustainability) may also be the answer to growing global concerns about food insecurity with a population expected to reach 9 billion by 2050 (Béné et al., 2015).

Sustainable fishing, which involves practices that maintain fish populations and ecosystems without depleting resources or harming the aquatic environment, is key to addressing global ocean challenges. It requires managing and harvesting fisheries in ways that ensure their future productivity and health. This includes enforcing catch limits, using selective fishing gear to minimize bycatch, and conserving critical spawning and nursery habitats.

A variety of policy tools are being used around the world to promote sustainable fisheries and the conservation of marine ecosystems, from the establishment of marine protected areas with fishing restrictions to the implementation of catch shares or quotas. One emerging strategy is seafood ecolabeling. Ecolabels, such as the Marine Stewardship Council (MSC) label and the recently introduced French label called *Pêche Durable*, inform consumers about the sustainability of their seafood. These labels serve as market-based and educational tools to promote sustainable fishing practices and increase consumer awareness of sustainable seafood. As a result, sustainable seafood connects consumers to seafood, promotes improved fishing practices, and reduces environmental impacts.

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3.1.1 Seafood ecolabel

3.1.1.1 Introduction

Ecolabels play an important role in promoting sustainable fishing practices, thereby contributing to the protection of marine ecosystems and habitats. As a market-based instrument, ecolabels motivate both producers and consumers to support sustainable fishing practices (Gutiérrez et al., 2012). As in other sectors such as organic agriculture, fair trade, and sustainable forestry, certification is critical to ensuring that a fishery meets sustainability criteria.

The “MSC Pêche durable” label is the most widely used label in France and around the world. The MSC is an international non-profit organization founded in London in 1997. The first MSC-certified seafood products were introduced in 2000, and the program has grown from 150 certified products in more than 10 countries in 2003 to more than 26,000 products in approximately 100 countries as of August 2017. The evaluation of MSC certified fisheries primarily focuses on its impacts on fish stocks and marine ecosystems. Unlike other countries that have promoted private national standards (such as Iceland with its Island Responsible Fisheries logo) or international standards (such as Chile and Mexico with the MSC ecolabel), France has taken a different path with the creation of a public ecolabel, the *Pêche Durable* ecolabel. This label incorporates a unique approach that combines sustainable development criteria, thereby ensuring the independence and impartiality of the certification and effectively addressing the needs of the sector.

3.1.1.2 The Pêche Durable Ecolabel: A French initiative for sustainable fisheries

In parallel with other labels on the market (including MSC Pêche Durable label), the French government unveiled its own *Pêche Durable* label in 2017, the country's first public ecolabel. The Pêche Durable label (Figure 3.1) is classified as of a public certification scheme, alongside other quality and origins labels (SIQOs), and operates under the aegis of the French Rural and Maritime Fisheries Code. The initiative is managed by FranceAgriMer, a public agency under the Ministry of the Environment.

Figure 3.1: Logo of the French Pêche Durable label[51]

[51] Reproduced from : https://agriculture.gouv.fr/lecolabel-public-peche-durable

The genesis of the *Pêche Durable* label is attributed to two dynamics. Firstly, there was a political impetus, both at international and European level, to regulate fishing activity without undermining international trade. Second, an industrial dynamic, both national and international, allowed the private appropriation of the new tool in the absence of public adoption. This has led to a subsequent and defensive mobilization of French public action.

The need for a public ecolabel that would integrate the environmental, social, and economic aspects of the fishing industry was expressed by professionals in 2007. This request was favorably received by the *Grenelle de l'Environment*, which formalized it with a new law in 2008. The decree emphasizes that "sustainable fishery products can benefit from an eco-label", subject to certain conditions set out in a reference system. **Decree No. 2012-104 of January 27, 2012,** led to the creation of a commission to draft the standard. This commission was composed of representatives from all sectors of the fishing industry, the administration, NGOs, consumers, and scientists. Public opinion was gathered in two consultations (early and mid-2014) and the standard, together with the framework control plan, was approved on December 16, 2014.

The **certification process** covers two main aspects:

- **Upstream** (or Production): Fishing companies must apply for certification for a specific species x fishing gear x fishing area combination. If multiple combinations are considered, the standards' criteria must be met for all.
- **Downstream**: Operators in the marketing chain involved in sorting, processing, distribution, or storage of certified products, starting from the first marketing step to the sale to the final consumer should comply to the following criteria:
    - Sourcing from certified suppliers
    - Establishing a clear product traceability system
    - Ensuring the finished products are fresh and of high quality.

Prior to the certification process, certain **prerequisites** (PR) are reviewed. These include:

- Sustainable target rate of stock exploitation (PR1)
- An international management framework to maintain the eco-labelled stock within precautionary limits (PR2)
- No harm to marine species other than the target stock as a result of fishing activities (PR3).
- The flag state of the vessel is a signatory to the International Labor Organization (ILO) conventions on working conditions on fishing vessels (PR4).
- States implementing a strategy to achieve good environmental status of the marine environment by 2020 (PR5)
- Requirement to report lost fishing gear to a management body (PR6)

Production certification lasts **five years**, while **marketing certification** lasts **three years**. Follow-up audits are conducted annually to ensure continued compliance.

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3.1.1.3 Market mechanisms of the instrument for internalization

Figure 3.2 illustrates the pathways of effects from the implementation of a seafood label to changes on health, social and environmental externalities. Ecolabeling is a market-based mechanism designed to improve fisheries management and the sustainability of the world's marine resources (Washington, 2008). In this section, we describe three underlying mechanisms of the seafood ecolabelling system that may impact seafood consumption and production. First, we discuss the costs of labeling and certification, which can reduce market incentives. Second, we describe how the seafood ecolabel could improve public awareness of sustainable fishing. Third, we show that the labelling system may introduce some vertical differentiation between products and then affect market prices.

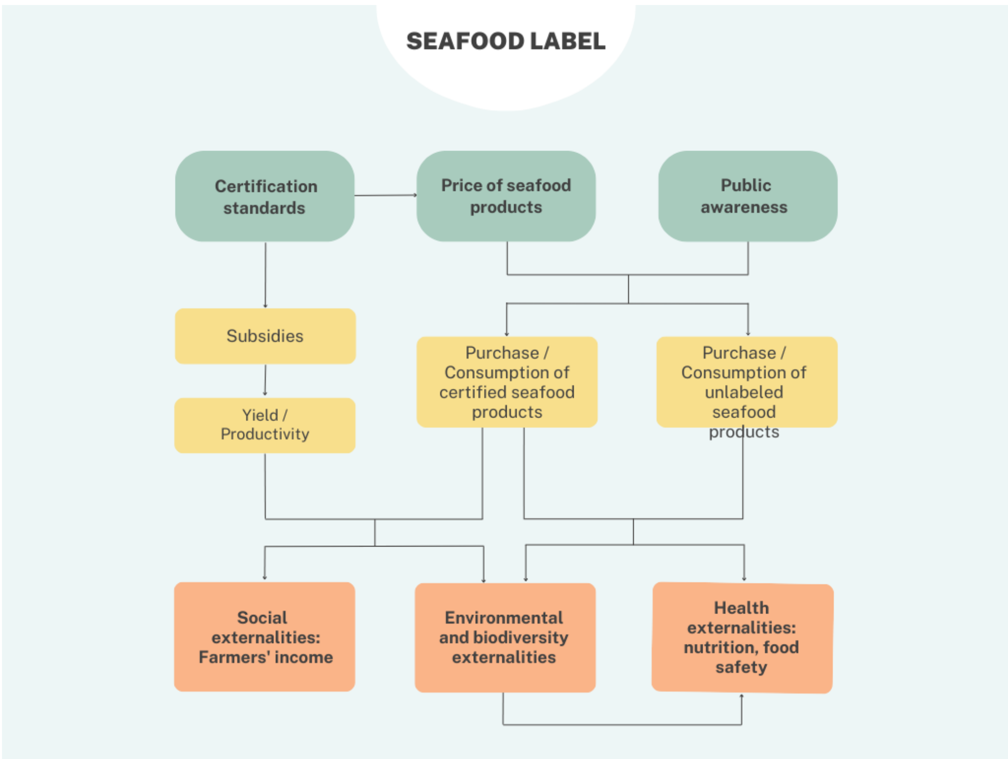

Figure 3.2: Pathways of Effects

3.1.1.3.1 Limitations of ecolabelling and certification: Impact on costs

As the Washington's study (2008) points out, ecolabelling and certification schemes face significant limitations. Achieving **certification** can involve significant **costs** for fisheries, including the direct costs of certification, changes in practices to meet sustainability standards, annual audits, and ongoing data collection and record keeping. These costs are often **borne by producers**, particularly small-scale fisheries, which may find them prohibitive, thus limiting the reach of ecolabels primarily to larger, more financially capable operators. Moreover, these cost burdens may not be commensurate with the benefits that producers derive from certification, which may diminish over time as more certified producers enter the market. In contrast, other actors in the supply chain, such as importers/wholesalers and retailers, often find the costs associated with certification to be worthwhile in terms of maintaining customer relationships and enhancing reputation, even though they receive many of the benefits of ecolabelling.

3.1.1.3.2 Public awareness

Public awareness and willingness to purchase certified products are key to the effectiveness of these labels. Ecolabels, such as *Pêche Durable*, serve as important market-based tools that provide consumers with the information they need to make sustainable seafood choices (Washington, 2008; Roheim et al., 2011; Christian et al., 2013).

Consumers show a preference for certified seafood and are willing to pay a higher price for these products. Based on a French survey of 911 respondents conducted from April to June 2010, Brécard et al. (2012) provide insight into consumer preferences for health, eco and fair-trade labels on seafood products. Preliminary analysis shows that only 6% of respondents select ”no label” as their preference, while 40% select ”health label”, 31% ”eco label” and 23% ”fair trade label”. The most favored label among seafood consumers is the health label, followed by the eco and fair-trade labels, suggesting a relatively low level of environmental awareness and altruism.

However, it remains uncertain how these labels influence consumer behavior, especially when negative environmental information is also communicated. Based on a survey of over 1,000 consumers, Salladarré et al. (2010), further confirmed by Brécardet al. (2012), Salladarré et al. (2013), investigate the demand for certified products in the French seafood market and finds that the production process and marketing characteristics (including geographical origin of seafood, whether the product is wild or farmed, fishing stock, and the state of the natural stock) has a stronger influence on demand for ecolabels than product attributes such as shape, visual appeal, and freshness.

In addition, Brécard et al. (2012) and Salladarré et al. (2016) show that socio-economic factors significantly influence label choice. According to Brécard et al. (2012), consumers who prefer ecolabels are more likely to be male, younger, and better educated, while Salladarré et al. (2016) show that WTP is positively correlated with income, environmental concern and trust in NGOs or public institutions.

Despite the reassurance that ecolabels provide to consumers about the impact of their seafood consumption on the marine environment, their proliferation among other ethical product differentiators may create "ethical confusion" that complicates purchasing decisions.

3.1.1.3.3 Impact on final price

The French seafood ecolabel, *Pêche Durable*, introduces a dimension of **vertical differentiation** into the seafood market. This differentiation, arising from variations in product quality that drive differences in prices, is largely influenced by consumer perceptions. Although the specific impact of the *Pêche Durable* label on seafood prices has not been quantified, existing academic research on similar ecolabels provides insight into potential effects.

In a stated choice experiment conducted in France, Chen et al. (2015) find a premium WTP for certified fish, with MSC-labeled wild cod commanding a 4% premium and organic-labeled farmed salmon and cod commanding an 11% premium. Building on this, Menozzi et al. (2020) evaluate consumer preferences and WTP for various fish species and their attributes, using a labeled choice experiment with 2,509 consumers from five countries: France, Germany, Italy, Spain, and the United Kingdom. Consumers are willing to pay a premium of €0.69 per kg for sustainably labeled fish. In a contingent valuation study, Salladarré et al. (2016) find that French consumers are willing to pay a maximum premium of about 10% of the product price.

European consumers outside France have also been shown to exhibit a willingness to pay for sustainably harvested seafood, indicating a strong potential for ecolabels to drive market changes (Sogn-Grundvåg et al., 2013). These results suggest that ecolabels can influence consumer behavior towards more sustainable choices, which still needs to be confirmed through actual purchases.

As a seal of assurance for sustainable fishing practices, the *Pêche Durable* label may impact the **market dynamics** of the seafood market. Producers can **transmit partly or fully the certification costs** and **charge a premium for certified products**, which can increase their market prices (Jaffry et al., 2004; Brécard et al., 2009; Roheim et al., 2011). Studies suggest that certified seafood often commands higher prices in Western markets, making sustainable alternatives economically attractive (Roheim et al., 2011, 2014; Foley et al., 2018). Conversely, products from producers who do not meet the label's sustainability requirements may face reduced demand, which can negatively affect their market position and product prices. The *Pêche Durable* label can thus create a market segmentation based on sustainability, influencing both consumer choice and market prices.

Additional costs associated with obtaining and maintaining *Pêche Durable* certification, such as those related to changes in fishing practices, audits, and product labeling, may also be passed on to consumers. The exact price impact may vary depending on factors such as the size of the operation, market demand, and how much consumers value sustainable seafood.

3.1.1.4 Policy impacts

3.1.1.4.1 Impact on consumption purchases

The French literature focuses on consumer preferences for different labels, including seafood ecolabels, and how they might contribute to marine conservation. It also examines how ecolabels and negative environmental information influence consumer behavior. Unfortunately, to the best of our knowledge, the impact of the new French *Pêche Durable* label on consumer purchases has not been studied. We then rely on other seafood label studies (such as the MSC label system) to provide insight into these effects on consumer purchases.

3.1.1.4.2 Impact on externalities

Seafood ecolabels, such as the *French Pêche Durable* ecolabel, aim to mitigate externalities and help achieve Sustainable Development Goal (SDG) target 14.4. This goal aims to regulate fishing, end overfishing and destructive practices, and restore fish stocks to sustainable levels. The ecolabel certifies fisheries that meet strict standards for environmental conservation, protection of marine ecosystems, and fair labor practices, in line with the goals of zero hunger and zero poverty.

However, there is currently a lack of specific literature examining the impact of the French seafood eco-label *Pêche Durable* on externalities and its effectiveness in promoting sustainable fishing practices and increasing the value of the fishing industry.

3.1.1.4.2.1 Impact on the environment and biodiversity

When analyzing the environmental impacts of seafood products, it is important to distinguish between the impacts that occur during the **fishing phase** and those that occur during the subsequent **post-landing phases of the product's life cycle**. It is also important to distinguish between different types of impacts.

3.1.1.4.2.1.1 Impacts occurring in the fishing stage

3.1.1.4.2.1.1.1 Pollution reduction

Harmful pollutants include **ghost gear** (i.e., abandoned, or lost fishing gear) that entangles and kills marine life, and marine debris such as plastics that break down into harmful microplastics (Macfadyen et al., 2009, Gilman, 2015, Kuczenski et al., 2022).

The *Pêche Durable* label encourages environmentally friendly practices that can help reduce pollution. The label not only limits direct pollution (Christian et al., 2013, Gutiérrez and Thornton, 2014) by reducing bycatch and using less harmful fishing gear, with less plastic, but it also contributes to an overall reduction in marine pollution. However, the effectiveness of these labels varies depending on factors such as rigorous standards, certification credibility, market demand, and accessibility for small-scale fisheries (Jacquet and Pauly, 2007, Gutiérrez et al., 2012).

3.1.1.4.2.1.1.2 Effect on Ecosystems and Habitats, and Protection of Marine Fauna & Flora

Overfishing has **adverse effects** such as significant **species loss**, **disruption of food chains** (Myers and Worm, 2003), **habitat degradation** (Watson et al., 2004), and potential **cascading effects throughout marine ecosystems** (Jackson et al., 2001, Pauly et al., 2005, Worm et al., 2006). It can create imbalances by favoring certain species while depleting others, thereby altering species composition and potentially disrupting ecosystem equilibrium (Myers and Worm, 2003). In addition, the presence of fishing debris, particularly derelict fishing gear and organic waste, indirectly affects marine biodiversity (Gilman, 2015). Long-term threats are exacerbated by the introduction of non-native species and the ingestion of contaminants such as PCBs from plastics (Derraik, 2002; Gilman, 2015; Kuczenski et al., 20-22; Nicolas, 2020).

In Europe, seafood ecolabels have become a valuable tool in the fight against overfishing. While research specific to the *Pêche Durable* ecolabel is limited, seafood ecolabels in general contribute to sustainable fisheries management (Gulbrandsen, 2009, Roheim et al., 2011) through increased monitoring, compliance with catch limits and conservation of biodiversity (Froese and Proelss, 2012, Jacquet et al., 2010). By establishing rigorous certification standards, these labels can improve the protection of marine habitats and ecosystems.

3.1.1.4.2.1.1.3 Stock Status and Fishing Pressures, The Uses of Selective Methods, Reduction of Bycatch

Fishing activities inevitably have an impact on target and non-target species, as well as on the wider marine ecosystem (Thrane et al., 2009). Seafood ecolabels, including the French *Pêche Durable* ecolabel, play a role in addressing these impacts by requiring fisheries to maintain stocks at sustainable levels, reduce fishing pressure, and promote the health of fish populations. Ecolabels also encourage the use of more selective fishing gear and methods to meet certification standards, thereby minimizing the unintentional catch of non-target, juvenile, or endangered species (Froese and Proelss, 2012, Gulbrandsen, 2009).

3.1.1.4.2.1.2 Impacts occurring in later, post-landing phases of the products life cycle

3.1.1.4.2.1.2.1 Waste Avoidance

Marine ecosystems face significant threats from fishing industry waste, including habitat destruction and mortality of non-target species (Free et al., 2014). Ecolabels may play a crucial role in promoting sustainability in seafood production by reducing waste sources within the industry (Gulbrandsen, 2009). They achieve this through strict sustainability standards that **minimize bycatch, discards, and destructive fishing practices**. For example, the French seafood eco-label focuses on waste reduction by regulating bycatch and promoting the use of fishing gear designed to minimize unwanted catches (Gutiérrez et al., 2012). In addition, ecolabels improve traceability and discourage illegal fishing practices such as unreported and unregulated fishing.

Moreover, market-driven forces behind these labels incentivize waste reduction by appealing to consumers' environmental concerns, fostering a market for sustainable fishing practices, and empowering consumers to make informed choices about sustainably sourced seafood (Gutiérrez et al., 2012, Roheim et al., 2011).

3.1.1.4.2.1.2.2 Reduction of fossil energy

The role of the fishing industry in fossil fuel consumption is significant, accounting for approximately 1.2% of global oil consumption (Tyedmers et al., 2005). This consumption varies widely, depending on factors such as the type of fishing gear used, target species, and fishing grounds. For example, large fishing vessels consume large amounts of fuel and contribute significantly to global CO_2 emissions (Parker and Tyedmers, 2015), as well as global warming, nutrient enrichment, and acidification. The environmental footprint of the seafood industry extends beyond fishing operations to the post-landing product chain, which includes processing, wholesaling, and transportation.[52] Despite the recognition of the FAO Code of Conduct for Responsible Fisheries (1995), energy use remains under-discussed in the dialogue on sustainable fisheries (Thrane et al., 2009).

Although no paper has directly estimated the impact of seafood certification on energy, existing studies provide insights into its potential role in reducing environmental impacts. Thrane et al. (2009) and Tlusty (2012) discuss how ecolabeling initiatives, such as the MSC label, could incentivize the fishing industry to reduce energy consumption and emissions. Tlusty (2012) even proposes a pull-threshold model to encourage producers to improve their environmental impacts, including energy consumption. The *Pêche Durable* label in France, along with other seafood ecolabels (Christian et al., 2013, Froese and Proelss, 2012), is an example of how energy efficiency measures can be promoted to reduce the sector's carbon footprint (Jacquet et al., 2010).

Despite the potential of eco-certification to reduce environmental impacts, a global perspective is needed to identify the most energy-efficient seafood production and distribution methods (Tlusty et al., 2009; Madin and Macreadie, 2015; Vázquez-Rowe et al., 2016). Moreover, their effectiveness varies, and integration of carbon footprints is often lacking (Tlusty, 2012; Madin and Macreadie, 2015).

3.1.1.4.2.2 Impact on social and health externalities

3.1.1.4.2.2.1 Social externalities

3.1.1.4.2.2.1.1 Fair Wage and Living Income: Zero Poverty Objective

[52] See Tlusty et al. (2009) and Vázquez-Rowe et al. (2016) for seafood production and distribution costs.

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Promoting **fair wages** and **poverty reduction** in the seafood sector are primary objectives of the Pêche Durable label. Its impact is mainly multifaceted and dependent on context.

Ecolabels focus primarily on improving the sustainability of fisheries, which indirectly benefits fishing communities (Roheim et al., 2011). By stimulating market demand for sustainable seafood and commanding price premiums, ecolabels have the potential to increase wages and incomes in the fishing sector (Roheim et al., 2011; Gutiérrez and Thornton, 2014), as well as fishers' livelihoods (Bush et al., 2013) in both developed and developing countries.

However, the benefits of ecolabels are often unevenly distributed, favoring larger and wealthier fisheries that can afford certification costs, potentially leading to inequities. Smaller or poorer fisheries may be excluded from these potential benefits due to high certification and maintenance costs (Jacquet et al., 2010).

3.1.1.4.2.2.1.2 Food Security: Zero Hunger Objective

With the global population expected to reach 9 billion by 2050, underutilized seafood sectors such as fisheries and aquaculture could be key to addressing food insecurity in the long term. Fishing-related activities already contribute to the food security of more than 10% of the world's population (Béné et al., 2015).

Ecolabels, while promoting sustainability and improving fisheries management, have a complex impact on food security, influenced by the scale of fishing and resource availability. They ensure the continued availability of seafood, an important global source of protein (Gulbrandsen, 2009; Bush et al., 2013).

However, ecolabels may inadvertently marginalize small-scale fisheries that are unable to meet certification requirements (Jacquet and Pauly, 2007; Jaffry et al. 2004), potentially threatening local food security.

3.1.1.4.2.2.2 Health externalities

3.1.1.4.2.2.2.1 Nutrition

Fish, which provides more than 4.5 billion people with at least 15% of their average per capita animal protein intake, has unique nutritional properties that are essential for the health of consumers worldwide, in both developed and developing countries in the long term (Béné et al., 2015). The French seafood eco-label *Pêche Durable* has the potential to reinforce these health benefits by making sustainably sourced seafood more accessible and appealing to a wider population. As more ecolabels may attract new consumers, the public health impact of seafood consumption in general could be significantly improved, offering people healthier dietary choices, and promoting well-being on a broader scale.

3.1.1.4.2.2.2.2 Food Safety

Eco-labels such as *Pêche Durable* have emerged as a key assurance of **rigorous safety and quality standards**.[53] Specifically, *Pêche Durable* requires strict criteria that embed food safety protocols into its standards. These include requirements for high levels of cleanliness in fishing vessels and processing facilities, careful handling of the catch, and prompt and proper preservation to prevent spoilage and maintain freshness.

In addition to safety and quality assurance, traceability is an important element of ecolabels, helping to marginalize illegal, unreported, and unregulated (IUU) fishing. In addition, ecolabels such as *Pêche Durable* can also influence the reduction of practices that introduce toxins and chemical contaminants into marine food webs (Kuczenski et al., 2022), thereby contributing to seafood quality.

3.1.1.4.2.3 Impact on economic externalities

The French seafood ecolabel may play a crucial role in the sustainable fishing industry in France and beyond. The literature suggests that ecolabels in the seafood industry can potentially impact **employment**, though the relationship is complex and can depend on various factors. Gulbrandsen (2009) finds that the MSC certification can lead to market differentiation and expansion, potentially creating new job opportunities. Also note that in terms of aquaculture, ecolabeling has been found to promote best practices, incentivize innovation, and potentially stimulate job growth (Bush et al., 2013). However, it was also found that smaller fisheries may struggle with the cost of achieving and maintaining certification, potentially impacting their profitability and employment (Gutiérrez et al., 2012; Jonell et al., 2013).

In addition, the eco-label has helped to boost the **tourism industry** as tourists become more aware of their seafood consumption and choose restaurants and seafood shops that sell ecolabeled products (Schuhbauer and Sumaila, 2016). Moreover, by reducing the amount of derelict fishing gear that can end up in inshore habitats, ecolabels can enhance the socio-economic values of recreation, tourism, education, and research, and positively impact residential and commercial uses.

[53] Research by Salladarré et al. (2010) shows that French consumers associate eco-labeled seafood not only with environmental sustainability, but also with improved quality and safety.

3.2 Biodiversity and ecosystemic services

Key findings

- Biodiversity, natural resources, and ecosystem services are essential for human survival and well-being and influence ecosystems, health, and climate change. Europe, home to 15% of the world's biodiversity, is experiencing significant species loss due to habitat degradation and climate change.

- To address this challenge, the EU has initiated several policies, such as the European Green Deal and the Biodiversity Strategy for 2030. France has implemented strategies such as agroecology, certification and labeling schemes, and regulatory solutions.

- The High Environmental Value (HVE) certification, introduced after the 2008 Grenelle Round Table on the Environment, recognizes farms that adopt environmentally friendly practices. It uses performance indicators related to biodiversity, pesticide use, fertilizer management and irrigation. The HVE logo can be used on products that contain at least 95% raw materials from HVE-certified farms, serving as a signal of sustainability to consumers.

- By 2022, HVE-certified farms represent about 7.7% of French farms and cover 5.8% of the French utilized agricultural area. Certification can be achieved through two methods that emphasize ecological infrastructure and reducing the weight of inputs. Studies suggest that HVE certification can lead to uncertain positive environmental and economic results in the medium term.

- The European Union and France have implemented agri-environmental measures, such as requiring grass strips along water bodies, to prevent soil erosion and water pollution from agricultural runoff.

- Grass strips may lead to significant economic losses for farmers due to land use restructuring and increased costs to eradicate invasive plant species resulting from reduced pesticide use at the short term. In the long run, however, the literature suggests mixed findings regarding their impact on productivity and yields.

- Some studies highlight the potential benefits of grass strips on biodiversity and the environment, both terrestrial and aquatic. These benefits include increased predator diversity, enhanced soil carbon stocks, and increased species richness in certain habitats, as well as a reduction in logging operations. The introduction of riparian buffer strips could also contribute to enhanced environmental amenities that are highly valued by households living nearby.

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Biodiversity, together with natural resources and ecosystem services, constitutes the life-support system essential for human survival and well-being. In the EU, and in France, these components contribute significantly to environmental, social, and economic prosperity. More precisely, biodiversity has an impact on ecosystems, affecting food systems, health, innovation, job creation, climate change mitigation and conflict prevention.

With approximately 100,000 known species - about 15% of the world's total biodiversity - Europe is witnessing the extinction of nearly a third of its native species due to habitat degradation, overexploitation, pollution, invasive alien species and climate change. Terrestrial and aquatic biomass, especially entomofauna, is also in alarming decline. In metropolitan France, 14% of mammals, 24% of reptiles, 23% of amphibians, and 32% of breeding birds are at risk of extinction. Forests, grasslands, and oceans are becoming unbalanced worldwide, and thousands of animal species are threatened with extinction. The rate of species extinction is between one hundred and one thousand times higher than the natural rate (Dasgupta, 2021). 34% of fish stocks are estimated to be overfished, and some 178 million hectares of forest have been lost since 1990.

To address these escalating threats, the EU has initiated several policies, such as the European Green Deal, the Biodiversity Strategy for 2030, the Farm to Fork Strategy, and the new EU Common Agricultural Policy (CAP) for 2021-2027. The CAP emphasizes climate change mitigation and adaptation, the efficient management of natural resources such as water, soil and air, and the protection of biodiversity and enhancement of ecosystem services.

France is proactively addressing these multiple challenges through the concept of agroecology including certification and labeling schemes, such as the High Environmental Value certification, together with regulatory solutions such as the introduction of riparian grassy strips.

3.2.1 Agroecology

3.2.1.1 Introduction

In a context of environmental and climate issues, the adoption of sustainable, resilient, and nature-compatible agricultural practices is becoming increasingly crucial. Agroecology offers an innovative approach and compelling solution in France to designing production systems that capitalize on ecosystem functionalities. This method ensures natural resource conservation while mitigating environmental burdens, such as greenhouse gas emissions and pesticide use. This holistic perspective also fosters simultaneous maintenance and enhancement of technical and economic results, improving environmental performance. Moreover, agroecology champions diversity restoration in agricultural systems, helping the creation of a diversified landscape mosaic and reinforcing the role of biodiversity as a crucial production factor.

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3.2.1.2 Label "Haute Valeur Environnementale"

The High Environmental Value certification (*Haute Valeur Environmentale,* HVE) is an eco-labelling scheme that France introduced in 2011 following the 2008 Grenelle Round table on the Environment (**Law No. 2010-788**, known as **Grenelle II law**, Art. 109). The objective of this voluntary certification is to identify and promote agricultural operations that specifically focus on preserving the ecosystem and biodiversity on their farms. More precisely, HVE adheres to the principles of agroecology: designing systems based on ecosystem functions like soil fertility and protective fauna; targeting agricultural production with minimized environmental impact, including greenhouse gas reduction and water resource conservation; sustainably using natural elements for production, such as green manure cover crops and agroforestry; and promoting system and landscape diversity through crop diversification and agroecological infrastructure. Table 3.1 describes the main similarities and differences between HVE certification and organic farming.

HVE is considered as the highest of the three-level approach that includes "Environmental Farming Certification", "Environmental Certification of Farms", and "High Environmental Value". HVE is a result-based approach that uses environmental performance indicators related to biodiversity conservation, reduction in the use of phytosanitary products, fertilization management, and water resource (irrigation) management. Farmers can choose between two types of HVE certification. These two types of certifications rely on two different methods:

- The first method, **"Option A"**, involves scoring in four areas based on various indicators. The farm will receive HVE certification if it achieves a score of more than 10 points for each of the four themes.
- The second method, **"Option B"**, uses global indicators. In this case, certification is awarded if two conditions are met:
  - (i) Either the percentage of Utilized Agricultural Area (UAA) dedicated to agroecological infrastructures[54] (equivalent to semi-natural habitat) is equal to or greater than 10%, *or* the percentage of UAA in permanent grassland is equal to or greater than 50%.
  - (ii) The weight of inputs in the turnover is less than or equal to 30%.

In order to incorporate HVE certification into the 2023 CAP National Strategic Plan (NSP), the reference system was revised in 2022 and implemented from January 1, 2023. This revision aimed to enhance the overall level of requirements by eliminating "option B" and introducing new elements that prioritize "option A" with more stringent criteria. These criteria include the use of environmentally friendly organic nitrogen, the

[54] In agricultural production systems, agroecological infrastructure is mainly hedgerows, woodlots, scattered or aligned trees, buffer strips, extensively managed meadows, low walls, benches, ponds, high-stem orchards, and all environments (e.g. agroforestry) and areas that do not receive fertilizers or pesticides.

presence of parcels smaller than 6 hectares, and the exclusion of certain harmful products.[55]

According to Article L. 611-6 of **Decree No. 2011-1914** of December 20, 2011, on the development of the label "from a farm of high environmental value", only agricultural products, whether processed or not, that come from farms of high environmental value can be labeled as such for the sake of transparency. The HVE logo (see Figure 3.3) can be used on both processed and unprocessed products that contain at least 95% of raw materials from HVE certified farms. The logo allows consumers to recognize the efforts made by these farms and provides a potential premium for farmers marketing agroecological products.

Figure 3.3: Logo of the HVE certification (on the left) and HVE product (on the right)[56]

By July 1, 2022, 7.7% of French farms are HVE certified, covering 5.8% of France's agricultural area. In 2023, HVE certifications increase in all sectors, especially in livestock farms (20.3% of farms), reducing the share of wine-growing farms to 62.3% (against 74% in 2022).[57]

[55] The revised version has introduced a disqualifying point under the “Phytosanitary” indicator. if a farm uses products classified as CMR1 (carcinogenic, mutagenic or toxic to reproduction), the "Phytosanitary" indicator will be invalidated and the farm will lose its certification.
[56] Reproduced from: https://agriculture.gouv.fr/certification-environnementale-mode-demploi-pour-les-exploitations
[57] Source: https://agriculture.gouv.fr/les-chiffres-cles-de-la-haute-valeur-environnementale-hve

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Table 3.1: Main similarities and differences between organic farming and HVE certification

		HVE certification	Organic farming
	Logo		
Main differences	**Description**	Certification at the farm level, supervised by the French public authorities	Quality labelling and certification scheme, governed by a set of specifications defined at the European regulatory level and that can relate to a product, whether processed or not.
	Main externalities	Adopting environmentally friendly practices (*agroecology)*	Reducing the consumption of synthetic chemicals
	Primary targeted externalities	Environmental	Environmental, social and health
	Certification standards	Focused on 4 themes: - biodiversity - fertilization - crop protection - water management	Based on stringent standards for agricultural production, including - the use of natural fertilizers, - the prohibition of synthetic pesticides, - crop rotation, and - animal welfare
	Targeted economic agents	Farmers	Throughout all the food supply chain from the production of raw materials, to processing and distribution
	Implementation level	France	European Union
Main similarities	**Monitoring**	Monitored *in situ* by independent certifying bodies	

	Product labeling	Yes
	Volontary vs. Compulsory	Voluntary
Complemen-tarities	A farm can be under both organic farming and HVE	

Sources: Adapted from the website of French Ministry of Agriculture and Food, 2016 (https://agriculture.gouv.fr/bio-et-haute-valeur-environnementale-deux-modes-de-valorisation-complementaires)

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3.2.1.3 *Mechanisms of the instrument for internalization*

Figure 3.4 illustrates the pathways from implementation of the HVE eco-label (as an eco-label) to changes in environmental and biodiversity externalities, as well as social and health externalities. In this section, we describe the three underlying mechanisms of the HVE-labelling system. First, we present the effect on the certification standards and **costs** in terms of pesticide reduction, subsidies, and yields and productivity. Second, we discuss how the labelling system may introduce some vertical differentiation between products and then affect **market prices**. Third, we describe how the HVE label could improve **public awareness of agroecology principles** through HVE certification and how labelling scheme could improve the efficiency of the policy.

To date, there is no clear evidence regarding the magnitude and direction of the impacts of these economic mechanisms in contributing to externalities. This conclusion primarily arises from the absence of quantitative data on HVE certification, as well as the recent implementation of this scheme limited to France only.

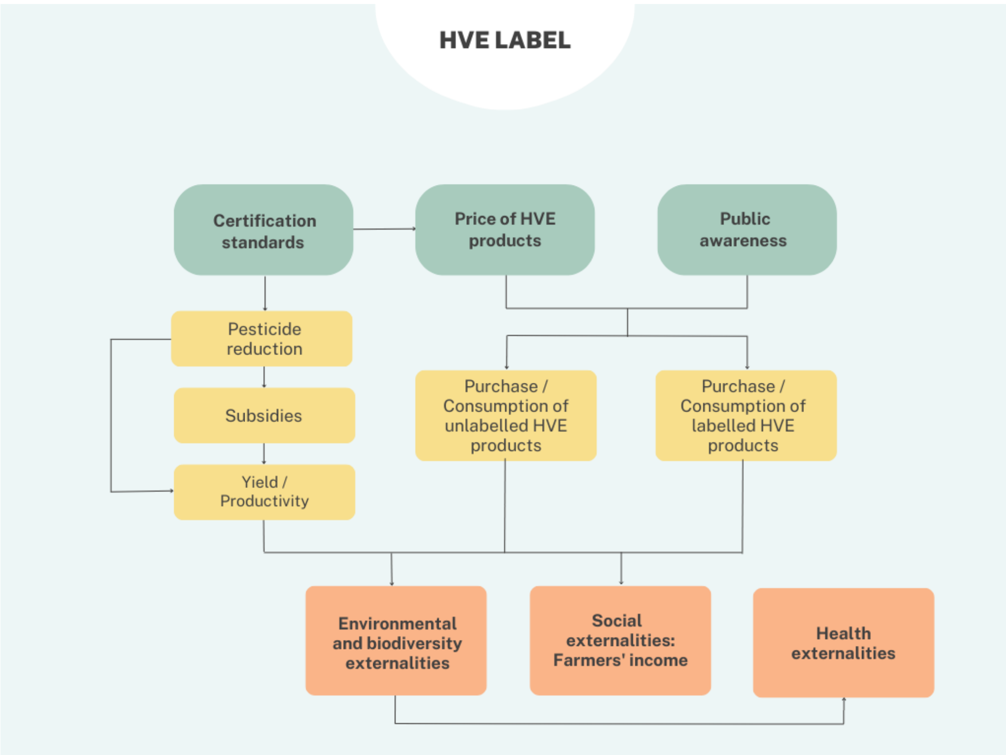

Figure 3.4: Pathways of Effects

3.2.1.3.1 Certification standards and impact on costs

3.2.1.3.1.1 Pesticide reduction

HVE certification places emphasis on maintaining biological balance and enhancing biodiversity, aligning with the National Strategy for Ecological Intensification of Agriculture in France. HVE requires farmers to adopt environmentally friendly practices, reduce the use of chemical inputs, and implement Integrated Pest Management (IPM). For instance, promoting the growth of natural predators and introducing pest-resistant plant varieties can effectively minimize the reliance on synthetic pesticides. Additionally, the use of biocontrol agents such as insects, fungi, and bacteria, which act as natural enemies of pests, is also encouraged, further reducing the necessity for pesticides.

Implementing such environmentally sustainable practices required by HVE may result in higher production costs for farmers due to factors such as additional labor or investments needed to meet the certification's stringent life cycle assessment requirements. The costs associated with certification and the investments needed to obtain it may sometimes exceed the economic benefits of certification, although no evaluation exists on this subject.

However, since the HVE certification provides access to “Level 2 environmental schemes” under the new CAP program without the constraints of crop rotation diversity and maintenance of permanent grassland, farms are exempt from strategic phytosanitary advice. More importantly, pesticide reduction is not a mandatory requirement of HVE certification *stricto sensu*, which further complicates the evaluation of this policy. Only two studies (Grémillet and Fosse, 2020a,b) have examined HVE certification. They compare the "option A" and "option B" methods (prior to the 2022 revision) of HVE certification with organic farming. The research shows that HVE certification performs better than organic farming in terms of ecological functionality, as measured by "biodiversity" and "resources" scores. However, it falls short in input reduction compared to organic farming.

3.2.1.3.1.2 Access to CAP subsidies beyond HVE certification

Unlike organic farming and other agri-environmental and climate-related schemes (MAEC), HVE farms committed to environmental certification do not receive *specific* public financial support. However, HVE adopters may be eligible for support pertaining to other schemes. Farms pursuing certification can receive a tax credit to assist their endeavors and may receive an augmentation in the young farmer's subsidy during the commitment period, thereby promoting sustainable practices among young farmers. Moreover, a farm can be bother under organic farming and HVE. For example, farmers already certified under organic farming can ask for the HVE certification to highlight her efforts made in terms of biodiversity and the preservation of natural elements at the farm level.

3.2.1.3.1.3 Impact on yield and productivity

The impact of HVE certification on yield and productivity is a complex matter as it necessitates finding a balance between environmental stewardship and agricultural production. HVE certification promotes sustainable farming practices that may not prioritize maximizing short-term yields. In the short term, transitioning to more sustainable farming practices, as mandated by HVE, can potentially result in decreased yields. This is often observed when farmers reduce their use of synthetic fertilizers and pesticides, which initially may lead to lower crop yields and reduce their self-sufficiency (Grémillet and Fosse, 2020b).

In medium and long terms, agri-environmental farms generally show better economic results net of CAP subsidies compared to conventional farms (Grémillet and Fosse, 2020b). Indeed, the practices advocated by HVE, such as enhancing soil health and biodiversity, can improve farm resilience and potentially lead to more consistent yields over time. This becomes particularly relevant in the face of environmental challenges like drought and pest outbreaks. Therefore, over the long term, HVE certifications promote the sustainability and resilience of farming systems, which can potentially contribute to increased yields and productivity.

3.2.1.3.2 Impact on final price

HVE certification is expected to have an impact on product prices due to the principles of supply, demand, and the added value associated with sustainable agricultural practices. To offset higher production costs and maintain the economic viability of sustainable farming practices, farmers may need to charge higher prices for their HVE-certified products.

On the demand side, consumers may be increasingly willing to pay premium prices for sustainably produced and certified products, a trend that is likely to apply to HVE-certified products.

3.2.1.3.3 Public awareness

Ecolabels, such as the HVE label, play a crucial role in enabling policymakers to enhance consumer awareness regarding environmentally friendly product choices. These labels not only bridge the gap between producers and consumers but also uphold agricultural specifications, thereby supporting the entire value chain. Similar to the organic farming label, the HVE logo offers a unified visual identity for certified products. This assists consumers in easily identifying HVE products and facilitates their nationwide marketing by HVE adopters. Consumer behaviors towards labeled food may be shaped by positive attitudes towards the environment, food safety, and better alternatives to conventionally grown food (Azzurra et al., 2019; Hsu and Chen, 2014).

While there is no literature exploring the direct impact of HVE certification and labeling on public awareness, valuable insights can be gleaned from studies conducted on other **quality labels**, especially organic farming.

The literature on labeling schemes shows that the success of certification programs in the marketplace depends on **consumer awareness, understanding** and

knowledge, as well as **trust** in quality labels. This is particularly true for the organic label.

Many consumers, especially in Europe, have *limited* knowledge about organic certification schemes and logos (Van Loo et al., 2013; Zander, 2014; Zander et al., 2015). In the case of HVE label, its impact of the HVE label may be limited given its recent introduction and complex four-dimensional rating system. This complexity may make it less understandable to consumers compared to more established labels such as organic (Janssen and Hamm, 2012b).

The HVE certification and labeling have received criticism from organic farming advocates, despite the implementation of new revised standards. These advocates argue that the policy enables "greenwashing" and leads to consumer deception. On January 22, the French National Federation of Organic Agriculture (FNAB) and similar groups appealed to the French Conseil d'Etat, accusing the HVE label of perpetuating this deception. They strongly believe that the environmental and health benefits of HVE are being underestimated.

3.2.1.4 Policy impacts

3.2.1.4.1 Impacts on the environment and biodiversity

HVE certification includes elements such as biodiversity conservation, strategic crop protection, responsible use of fertilizers, and efficient water resource management. However, challenges, implications, and unresolved debates surround its use. Indeed, with the 2022 revision, HVE certification has recently implemented restrictions on the use of harmful pesticides, which have a negative impact on environment and biodiversity externalities (see Section 1.1 on pesticide-related policies).

3.2.1.4.2 Impacts on health and social externalities

3.2.1.4.2.1 Impact on public health

Health externalities are indirectly addressed by improving environmental externalities through the implementation of HVE. Depending on pesticide usage on individual farms, there may be positive public health effects. However, as mentioned earlier, unlike organic farming, the reduction of chemical inputs is an objective rather than a requirement. As a result, it is challenging to predict the impact of HVE certification/labeling on occupational and food exposures.

3.2.1.4.2.2 Impact on social externalities

Although the HVE label aims to promote environmentally friendly agricultural practices, it is limited in its scope and does not cover all aspects of sustainable agriculture. It does not consider the social and economic impacts of agriculture, such as working conditions or effects on local communities. As previously discussed, eco-labels,

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such as the French HVE or organic farming labels, may have an impact on the economic dynamics of the agricultural sector, particularly in terms of farmers' incomes.

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3.2.2 Riparian grassy strips

3.2.2.1 Introduction

The intensification of agriculture has caused profound alterations in landscape structure and the depletion of semi-natural habitats (Denys and Tscharntke, 2002; Robinson and Sutherland, 2002), resulting in a significant decline in biodiversity (Butchart et al., 2010).

In the wake of this growing environmental concern, agri-environmental schemes have advocated for the introduction of semi-natural areas such as riparian grassy strips to foster biodiversity and enhance ecological services along watercourses (Aviron et al., 2009; Holzschuh et al., 2009; Riis et al., 2020). They aim to prevent soil erosion and water pollution caused by the runoff of fertilizers and pesticides. They are characterized by vegetation influenced by flooding, elevated water tables, and soil types, and are found in a variety of biomes, reflecting a complex ecological diversity tied to variable flood regimes, unique channel processes, and climatic changes (Naiman and Décamps, 1997; Ward et al., 2002; Gurnell et al., 2016).

3.2.2.2 Institutional background

The **2003 CAP reform** in the EU introduced “Good Agricultural and Environmental Conditions” (**GAEC**) as a measure to protect soil, water, and habitats. This policy framework led to the introduction of grass strips in France in 2005 **(EU Regulation 1290/2005)** to improve water quality and wildlife habitats. The **EU Water Framework Directive** has further emphasized the importance of riparian zones by considering them as "quality elements" of the hydromorphological conditions, requiring their study and assessment in terms of their ecological status.

In France, **Article 138 of the Grenelle II law** requires the establishment of uncultivated grass strips along the edges of water bodies in 2009. By law, riparian buffer strips must be maintained on the ground with a minimum width of 5 meters from the bank. This requirement excludes areas that are already paved or occupied by buildings, courtyards, or enclosed spaces, in accordance with applicable zoning ordinances.

3.2.2.3 Mechanisms of the instrument for internalization

Figure 3.5 illustrates the mechanisms derived from the implementation of riparian grassy strips on production costs in terms of (1) land reduction, (2) reduction in use of chemical inputs and weed risk, and (3) productivity and yields.

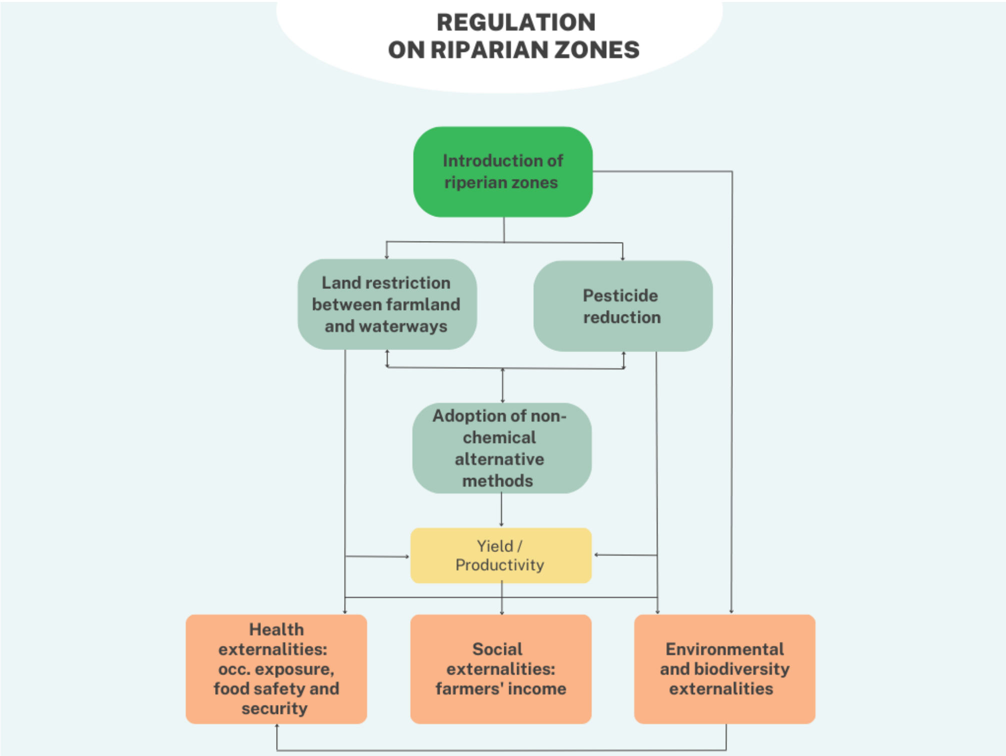

Figure 3.5: Pathways of Effects

3.2.2.3.1 Grassy strips implementation and impact on land use

The implementation of grassy strips along watercourses in France has brought about significant changes in land use patterns and management practices, particularly in the agricultural sector, where they may occupy valuable arable land (Bentrup, 2008). According to Corbeau et al. (2011), farmers have had to restructure their fields, dedicating about 3% of their total agricultural area to grassy strips.

3.2.2.3.2 Pesticide reduction and weed risk

Riparian grassy strips have proven to be highly efficient in **reducing pesticide runoff** that would otherwise contaminate watercourses (Syversen and Bechmann, 2004).

Despite these benefits, strips may inadvertently become hotspots for invasive plant species due to the prohibition of pesticide and fertilizer use (Amiaud and Touzard, 2004). Their proximity to field margins, which are historically rich in weed populations (Marshall, 1989; Fried et al., 2009), coupled with mowing practices that alter plant community composition, may facilitate the spread of noxious weed species (Westbury et al., 2008; Corbeau et al. 2011). Costs associated with annual mowing to suppress the growth of woody species and seeding recommended species can accumulate quickly (Mosnier et al., 2006).

3.2.2.3.3 Impact on yield and productivity

Implementing grass strips along watercourses poses challenges and opportunities for **crop yield** and **productivity**. The existing literature presents mixed findings regarding the direct impact of these riparian zones on yields. Initially, there may be a reduction in overall crop yield due to limited arable land availability (Corbeau et al., 2011). This land use restriction may lead to conflicts between conservation goals and agricultural productivity, potentially resulting in the loss of productive land (Bentrup, 2008). Weed risks are also a significant concern for farmers, as weed seeds can spread from these strips to adjacent farmland, negatively affecting agricultural productivity. However, in the long term, the grass strips can improve soil fertility, reduce soil erosion, and mitigate waterborne diseases that could harm crops, thus potentially increasing agricultural productivity.

3.2.2.3.4 Total policy cost implications and farmers' perception

Farmers may incur significant **economic losses** after the introduction of grass strips. While these strips provide substantial environmental benefits, their establishment and maintenance entail additional costs. Corbeau et al. (2011) estimate that farmers experienced significant economic losses due to grass strip implementation, with average losses ranging from 358 to 853€ per hectare in the first year and 126 to 641€ per hectare in subsequent years. This resulted in a 7% reduction in farm income, considering only 3% of the land was converted to grass strips. These costs are borne by farmers who do not receive any compensatory payments, a factor that is often crucial for their acceptance of such agri-environmental measures (Herzon and Mikk, 2007; Defrancesco et al., 2008). Despite some savings in pesticide and tillage expenses, the costs of managing the grass strips and the loss of potential crop production outweigh the savings in operating costs.

3.2.2.4 Policy impacts

3.2.2.4.1 Impacts on the environment and biodiversity

3.2.2.4.1.1 Biodiversity

3.2.2.4.1.1.1 Impact on aquatic biodiversity and ecosystems

Riparian zones, critical in shaping aquatic ecosystems, serve as nutrient transformers, habitats, and systems for water quality enhancement (Naiman and Décamps, 1997; Xiang, 2016). They influence biogeochemical cycles by absorbing nutrients and supplying organic matter, directly affecting water quality and surface runoff. However, their degradation threatens global freshwater biodiversity, necessitating their conservation (Dudgeon, 2006). Disturbances to these zones can impact organisms like

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freshwater fish and disrupt water clarity and food webs (Pusey, 2003; Baxter, 2005; Broadmeadow, 2004).

3.2.2.4.1.1.2 Impact on terrestrial fauna and flora

Riparian zones significantly influence terrestrial biodiversity by providing habitats for various organisms that contribute to environmental health and agriculture, such as pest control, pollination, and food web complexity (Fontaine et al., 2006; Jauker and Wolters, 2008; Schmidt et al., 2003; Brewer and Elliott, 2004; Arrignon et al., 2007; Pontin et al., 2006). For example, beneficial species like Carabid beetles and syrphid hoverflies, known for pest control and pollination, thrive in these zones (Schweiger et al., 2005; Desender et al., 1989; Asteraki et al., 1995; Dennis and Fry, 1992). Small mammals, like shrews, add to food web complexity (Millymaki, 1977; Shvarts et al., 1997; Salamolard et al., 2000; Butet et al., 2010; Tattersall et al., 2002; Macdonald et al., 2007). Acting as habitats, corridors, and overwintering spots, these zones help beneficial species colonize nearby fields (Spence 1979; Forman and Godron 1981, 1986; Malanson 1993; Duelli et al. 1990; Wiens et al. 1985; Mauremooto et al. 1995; Pickett and Cadenasso 1995; Wiens 1997). Studies emphasize the need for their careful management and conservation, as they serve as stable refuges for plant communities, and their characteristics impact faunal biodiversity, hence playing a crucial role in biodiversity conservation in agricultural landscape (Ernoult et al., 2013).

3.2.2.4.1.2 Impact on carbon sequestration and climate change

Grassy strips or riparian buffer zones along watercourses significantly contribute to carbon sequestration and climate change mitigation, acting as carbon sinks (Castro, 2021; Abdalla, 2019; Berg et al., 1996; Deines, 1980). They sequester carbon faster than traditional land, aiding in carbon neutrality goals, and positively influence local water cycles and microclimates (Van Vooren et al., 2017).

3.2.2.4.1.3 Impact on logging operation

Grass strips along French watercourses provide environmental protection by reducing soil erosion and preventing debris flows, but they also reduce harvesting areas, affect short-term timber yields, require additional maintenance, and create economic pressures on the industry. Despite initial challenges, these strips enhance the sustainability of forest ecosystems, potentially attracting environmentally friendly wood product markets and thus promoting the longevity of the logging industry.

3.2.2.4.2 Impacts on public health and social externalities

3.2.2.4.2.1 Provision of ecosystemic services and amenities

Riparian zones are multi-functional and offer a myriad of benefits in terms of socio-economic externalities. They enhance property values by offering scenic views and amenities and promote recreational activities while improving trail networks. In landscape planning, these zones control erosion from climate change and urban runoff, safeguarding structures. They enhance biodiversity and soil health when planted with perennial crops and can reduce flooding and erosion. Planting woody crops like poplar or willow can also protect agricultural land from wind (Osario et al., 2019).

3.2.2.4.2.2 Impact on public health

Grass strips along French watercourses have significantly improved public health by filtering agricultural pollutants, enhancing water quality, and reducing waterborne diseases (Sa, 2008). They support local communities, foster biodiversity, and control disease vectors like mosquitoes (Burdon, 2020). Additionally, these green spaces boost mental well-being, underlining the importance of natural environment access (Grellier, 2017).

3.2.2.4.2.3 Impact on farmers' income

The relationship between riparian zones and farm incomes, particularly in small French farms, remains uncertain. Corbeau et al. (2011) find that two-thirds of surveyed farmers perceive these grass strips as detrimental to their income. Farm size also appears to play a role, with Aubert (2009) showing that smaller French farms that adopt alternative strategies, including the establishment of riparian zones, appear to benefit from their survival and growth.

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Report on policies with internalised externalities at the EU, national, and regional levels

D2.1

MAPP individual reports

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Task 2.1 Individual report

Evaluating the role of EU food policies in internalising environmental and social externalities: A literature review

Deliverable type	Month and date of delivery
Report	May 2023

Work package	Leader
WP2	INRAe

Dissemination level	Authors
Internal	John Thøgersen, Anne Odile Peschel, Jason DiPalma

Programme	Contract Number	Duration	Start
Horizon Europe	101060481	48 Months	June 2022

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Preface

Aarhus University/MAPP was tasked with identifying relevant EU policies (i.e., to reduce or internalize externalities) that deal strictly with retailers. In addition to this, we evaluated additional policies outside our initial scope to help partners and ensure a more comprehensive report. We were limited to 1.5 person months for this task of the WP.

MAPP's methodology

For the continuation of this WP, we were asked to review the impact literature on specific policy **instruments** within a specific **thematic area**. Based on the overall scope of the FOODCoST project and focusing on the impact that European Union specific policy instruments have had in specific areas, and through communication with partners, we arrived at this Boolean search string for the literature search:

XXXXXX AND ("Evaluation" OR "impact" OR "effect") AND ("Food Safety" OR "Organic Farming") AND ("externality" OR "externalities" OR "spillover") AND ("European Union" OR "EU") AND ("prescription" OR "transparency" OR "monitoring" OR "penalties" OR "market placing" OR "placing on the market" OR "command and control" OR "command-and-control")

In this search string, *XXXXXX* represents the policy identifier for EU regulation numbers (e.g., 853/2004, 1020/2008, etc.)

The search was performed on Google Scholar as instructed by the WP leader. We obtained 318 articles related to nine EU regulations and 30 additional articles through snowballing. After closer screening, first on titles, then on abstracts, and finally on the full text, we ended up with 22 articles that were relevant for this report. Below is a short report of the results of the literature review.

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Chemical safety and biosafety

1.1 Food Safety

Food safety is a critical concern that affects every individual, regardless of their geographical location, socioeconomic status, or cultural background. It encompasses various practices and regulations aimed at ensuring that the food that society consumes is safe, wholesome, and free from any contaminants that could potentially harm public health and wellness. The motivation behind prioritizing food safety is rooted in the fundamental human right to access safe and nutritious food. A safe food supply is essential for maintaining good health, preventing foodborne illnesses, and reducing the burden on healthcare systems. Foodborne diseases can cause severe illness, hospitalization, and in some cases, even death. By implementing robust food safety measures, governments and regulatory bodies aim to protect consumers from these risks and ensure the safety of the food supply chain.

Food safety can be influenced by a multitude of external factors that extend beyond the control of individual consumers and producers. Some of these externalities include environmental contamination, improper handling and storage practices, inadequate infrastructure, and global trade. Environmental factors, such as contaminated soil, water, or air, can introduce harmful substances into the food chain. Additionally, poor sanitation practices, lack of proper refrigeration, or mishandling during transportation can contribute to the deterioration of food quality and safety. In the context of global trade, the potential for contamination increases due to the complexity of supply chains and the diverse regulatory frameworks across countries.

Taking all this into consideration, the European Union (EU) has implemented comprehensive regulations to safeguard food safety. The EU has attempted to harmonize standards to ensure the safety and quality of food products throughout the member states. Several key regulations play a crucial role in governing food safety within the EU and these regulations are expanded upon within the detailed instruments below.

1.1.1 Maximum residue level

A. Introduction

The only instrument identified that corresponded to this sub-thematic area is *Commission Regulation (EU) No 605/2010* (Regulation 2010) which harmonizes legislation regarding animal, public health, and veterinary certification conditions for the introduction of raw milk and dairy products intended for human consumption in the EU.

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This regulation aligns with existing EU directives and regulations on food safety and hygiene.

B. Description of the policy

The rationale for this policy is to ensure the safety and quality of raw milk and dairy products intended for human consumption by establishing animal and public health conditions and certification requirements. The main potential externality targeted by this policy is the risk to human health posed by the consumption of raw milk and dairy products contaminated with harmful substances or pathogens. The regulation aims to prevent such risks by establishing maximum residue levels for pharmacologically active substances in foodstuffs of animal origin.

The detailed design of the instrument includes specific requirements for certification, documentation, testing, sampling, analysis, labeling, packaging, transport, storage, and traceability of raw milk and dairy products intended for human consumption.

C. Mechanisms of the instrument for internalization

This policy changes costs and prices to facilitate the internalization of externalities along the food value chains, specifically targeting food safety risks. It establishes animal and public health conditions and certification requirements for raw milk and dairy products, imposing additional costs on producers and importers. These costs may be passed on to consumers as higher prices. However, these costs are necessary to ensure product safety and quality by preventing negative externalities.
The internalization mechanisms primarily affect industries and retailers involved in the production, processing, and distribution of raw milk and dairy products for human consumption. Producers and importers may need to invest in new equipment, testing, analysis, labeling, packaging, transport, storage, and traceability systems to comply with the regulation, thereby increasing production costs that should be passed on to the consumer. Farmers or producer organizations supplying raw milk may also be indirectly affected by the regulation, requiring additional investments to comply. Ultimately, consumers are affected by higher prices for raw milk and dairy products intended for consumption.

D. Policy impacts

No relevant articles were found related to *Regulation (EU) No 605/2010*.

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1.1.2 Standards, Certifications, and Labeling

Command and control instruments are a set of regulations that prioritize labeling, monitoring, and transparency within the realm of food safety. These policies play a critical role in facilitating the safety, quality, and transparency of food products within the EU. They address various aspects, such as organic production, good manufacturing practices, microbiological criteria, hygiene requirements, and novel foods. By enforcing stringent standards, promoting sustainable agriculture, and enhancing consumer confidence, these regulations contribute significantly to the overall objective of ensuring food safety.

1.1.2.1 Labelling

A. *Introduction*

Legal instrument *Commission Regulation (EC) No 2023/2006* (EC 2006) is a regulation on good manufacturing practices for materials and articles intended to come into contact with food. This regulation is part of the policy framework established by *Regulation (EC) No 1935/2004* on materials and articles intended to encounter food. The rationale behind this specific policy is to ensure the safety and quality of materials and articles used in food contact. The regulation establishes general and detailed rules on good manufacturing practice (GMP) for these materials and articles, including documentation requirements, quality management systems, and hygiene controls.

B. Description of the policies

The externalities targeted by *Commission Regulation (EC) No 2023/2006* include protecting public health by ensuring that materials and articles having food contact are safe, reducing the risk of contamination or adulteration of food products, and promoting consumer confidence in the safety of the food supply chain. The detailed design of the instrument includes requirements for documentation, quality management systems, hygiene controls, traceability, and labeling. The regulation has been amended several times to reflect changes in knowledge or technological developments. The regulation corresponds to the thematic area of food safety and the sub-thematic area of labeling by requiring appropriate labeling of materials and articles used in food contact to ensure traceability throughout the supply chain.

C. Mechanisms of the instruments for internalization

Commission Regulation (EC) No 2023/2006 does not directly change costs or prices to secure or facilitate the internalization of externalities along the food value chains nor does it have direct internalization mechanisms that change the final price or costs of food products. However, by ensuring the safety and quality of materials used in food contact, this policy indirectly contributes to internalizing externalities related to food safety, health effects of diets, and consumer rights. By reducing the risk of contamination or adulteration of food products, this policy can help prevent negative health effects and promote consumer confidence in the safety of the food supply chain which can lead to increased demand for safe and high-quality food products, potentially resulting in higher prices for these products.

The primary targets of this policy are industries that manufacture, process, or distribute materials and articles intended to come into contact with food. This regulation may indirectly affect production costs by requiring industries to implement specific measures such as documentation requirements, quality management systems, hygiene controls, traceability, and labeling. These measures may increase production costs for industries in the short term but can lead to long-term benefits such as improved product quality and consumer confidence. The internalization mechanisms of this policy primarily target producers and retailers since it regulates their packaging behavior.

D. Policy impacts

We have identified little literature on impacts from *Regulation 2023/2006*. Some EU countries, such as Germany and France, go above and beyond the established minimum regulation in the EU and uphold their own stricter regulations (Dahlberg et al., 2020). These regulations often entail specific tests, particularly for higher-risk materials like paper, board, bamboo, and wood.

1.1.2.2 Monitoring

A. Introduction

Commission Regulation (EC) No 2073/2005 (Commission 2005) is a legal instrument that considers microbiological criteria for foodstuffs. It was established in regards to *Regulation (EC) No 178/2002*, which lays down general food safety requirements and aims to ensure a high level of protection of public health.

B. Description of the policy

The rationale for this policy is to establish harmonized safety criteria on the acceptability of food, particularly with regards to the presence of certain pathogenic microorganisms. This is important for protecting public health and preventing differing interpretations among food business operators. In terms of externalities targeted, *Regulation (EC) No*

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2073/2005 primarily focuses on microbiological hazards in foodstuffs and their impact on human health.

The detailed design of the instrument includes establishing safety criteria for certain pathogenic microorganisms in foodstuffs (contributing directly to the area of food safety), as well as guidance on acceptable levels of these microorganisms during the manufacturing, handling, and distribution processes of the food chain.

C. Mechanisms of the instrument for internalization

This policy does not directly change costs or prices to secure or facilitate the internalization of externalities along the food value chains. Indirectly though, this policy could potentially impact prices by affecting the supply and demand of certain food products. In terms of externalities targeted, this policy addresses food safety and the impact of microbiological hazards on human health. It does not address internalization mechanisms.

This policy could indirectly impact costs and prices along the food value chain. For example, if a particular food product consistently fails to meet the established microbiological criteria, it may be subject to increased testing and monitoring requirements. This could lead to increased costs for food business operators, which could potentially be passed on to consumers through higher prices. Food business operators may need to implement additional controls on raw materials to ensure compliance with criteria, thereby impacting the price. The primary targets of this policy seem to be food business operators.

D. Policy impacts

No relevant articles were found related to *Regulation (EU) No 2073/2005*.

1.1.2.3 Transparency

A. Introduction

Legal instrument *Regulation (EC) No 852/2004* (Commission 2004a) outlines hygiene requirements for foodstuffs. This regulation is part of the broader policy framework for ensuring food safety within the EU. This policy provides considerable transparency as it requires businesses to maintain records related to their compliance with hygiene standards.

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Regulation (EC) No 853/2004 (Commission 2004b) was adapted to lay out specific hygiene rules for foodstuffs in the EU including specific requirements for establishments involved in producing and selling food of animal origin, such as structural, operational, and hygiene requirements.

Also included in the transparency sub-thematic is *Commission Regulation (EC) No 1020/2008* (Community 2008), which amends parts of *Regulation (EC) No 853/2004*. This policy framework is focused on ensuring continued food safety and protecting public health through its detailed design by establishing specific hygiene rules for food of animal origin, testing procedures, labeling, and identification markings.

Regulation (EU) 2015/2283 (Parliament 2015) deals specifically with novel foods. The detailed design of this instrument includes provisions for assessing the safety of novel foods (for consumption) before they are placed on the market, establishing a list of authorized novel foods, and ensuring that labeling requirements provide clear information to consumers. This adds to the transparency by providing clear information about the authorized novel foods to consumers.

B. Description of the policies

The rationale behind *Regulation (EC) No 852/2004* is to establish a uniform set of hygiene standards for food production and handling across all member states, with the goal of protecting public health while also reducing trade barriers for food products. The regulation sets out specific requirements for food businesses, including procedures for cleaning and disinfecting equipment, maintaining temperature controls, and preventing contamination. Health related externalities are targeted through addressing foodborne illnesses outbreaks, as well as issues related to consumer confidence in the safety and quality of food products. The detailed design of this instrument includes provisions for regular inspections and audits of food businesses to ensure compliance with hygiene standards. It also establishes penalties for non-compliance, including fines and potential closure of businesses.

The rationale behind *Regulation (EC) No 853/2004* was to establish common hygiene rules for food businesses in the EU, particularly those involved in producing and selling food of animal origin. This is necessary due to the specific microbiological and chemical hazards that can be present in these types of food products. The regulation also reduces negative economic externalities as it promotes fair competition among food businesses by ensuring that all operators follow the same hygiene rules. It also seeks to improve transparency and traceability in the food supply chain by requiring certain information to be included on labels and documentation.

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The rationale behind *Commission Regulation (EC) No 1020/2008* was to update and improve existing regulations in response to new scientific evidence and changing market conditions. The amendments were made to address identified risks related to certain fishery products, raw milk, dairy products, eggs, and egg products. The means to target externalities include information and increased transparency in the food supply chain by requiring identification markings for certain animal products. This helps ensure that consumers have access to accurate information about the origin and safety of their food. The rationale for *Regulation (EU) 2015/2283* is to ensure that novel foods placed on the market within the EU, including those imported from other non-EU countries, are safe for consumption and do not pose a risk to human health or the environment. The externalities targeted by this policy include spillover effects in food production processes, social externalities related to food safety and the promotion of innovation in food production, and protecting consumers' interests by providing them with accurate information about the food they consume.

C. Mechanisms of the instruments for internalization

Regulation (EC) No 852/2004, although it does not directly change costs or prices, could indirectly impact prices through compliance costs, thereby passing higher prices to consumers for food products. Especially, the regulation could indirectly impact production costs for food businesses through the investment of new equipment to meet higher hygiene standards. This policy primarily addresses food safety concerns and does not directly address other externalities. However, by improving food safety standards, it could indirectly contribute to improved public health outcomes and reduced healthcare costs in the long term. Hence, in this way it may internalize externalities in terms of potential health hazards through (marginal) changes in the final price of food products. This regulation primarily targets food businesses such as industries, retailers, restaurants, and food services. However, it indirectly impacts farmers who supply these businesses with raw materials by establishing hygiene standards that must be met throughout the entire food value chain.

In the same way, *Regulation (EC) No 853/2004* does not directly change costs or prices, but specific hygiene rules may require additional investments in equipment, training, and personnel, which will be passed to the end consumer. This regulation primarily targets food safety externalities related to microbiological and chemical hazards in food of animal origin. Additionally, by requiring clear labeling, it promotes fair competition among food businesses and improves transparency in the supply chain, which may help to reduce negative externalities associated with market power imbalances or unethical business practices. The primary targets of this regulation are food businesses operating within the EU, which includes farmers involved in producing food of animal origin, industries involved in processing these products, retailers selling them to consumers,

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and restaurants and food services that use them as ingredients. The indirect effects on costs and prices may impact all actors along the food value chain from farmers to consumers.

Also, *Commission Regulation (EC) No 1020/2008* may indirectly impact costs and prices along the food value chain by requiring food business operators to comply with specific hygiene rules and labeling requirements. Compliance may require additional investments in equipment, training, and testing procedures, which could increase costs for producers and processors. This policy primarily targets the food safety externality related to animal products. The internalization mechanisms of the instrument are primarily focused on changing production costs for food business operators. These increased costs could be passed downstream in the food value chain. In terms of input quantities and prices, compliance with hygiene rules could require changes in production practices or inputs such as feed or medication. For example, farmers may need to invest in new equipment or facilities to ensure that animals are kept in hygienic conditions. Overall, this instrument focuses on changing production costs for food business operators with the primary targets being farmers, producers, processors, and retailers who are involved in the production and sale of animal products.

Regulation (EU) 2015/2283 may indirectly affect costs and prices along the food value chains by influencing innovation in food production. For example, new technologies in food production may lead to cost savings for producers. Additionally, if novel foods are authorized for consumption, this could increase competition in the market and potentially lead to lower prices for consumers. This policy is about the protection of consumers, rather than changing costs or prices along the food value chain and there doesn't seem to be any internalization mechanisms that would change the final price of food products. This regulation may indirectly affect input quantities or input prices for producers by requiring them to comply with safety assessment requirements before placing novel foods on the market. This could potentially increase costs associated with testing and compliance measures. The primary targets of this regulation are producers who place novel foods on the market and consumers who consume these products.

D. Policy impacts

There is minimal literature investigating the actual impact that *Regulation 852/2004, 853/2004, & 2015/2283* have on health or other outcomes. For *Regulation (EC) No 1020/2008*, no relevant articles were found.

Recognizing the detrimental effects of contamination on both food quality and public health, the European Union (EU) has implemented measures to mitigate the presence of contaminants in food products (Arvanitoyannis 2008). Compulsory under *EU Directive*

93/43/EEC and *Regulation 852/2004/EC (EU 1993; EC 2004*), the use of Hazard Analysis and Critical Control Point (HACCP) principles at all levels of the food chain is mandatory, since January 2006, for all food business operators in the EU. Consequently, the early adopters have gained competitive advantages of HACCP, including cost savings and valuable learning experiences (Hanf & Pieniadz, 2007). So, HACCP procedures have been extensively employed to mitigate food safety risks and ensure compliance with minimum quality standards. However, the multitude of laws, regulations, standards, best practices, and codes unfortunately often leads to confusion, even among professionals who regularly work in the field and strive to stay updated with the latest developments (Raspor, Jevšnik, & Ambrožič, 2016).

This isn't the only controversy associated with these EU policies. There are calls for better parasite detection methods in fishery products as EU legislation is not effectively furthering parasite detection (Bao et al., 2019). For example, the parasitic disease Anisakis has an unacceptably high chance of reaching consumers with current detection methods. Also, Chalmers et al. (2020) echo the call for "well-trained operators" for Anisakiases detection.

Moral hazards regarding retailer compliancy can also be problematic (Hirschauer & Zwoll, 2008). Companies need to allocate resources (compliance costs) to ensure proper maintenance of cooling equipment and to train and motivate truck drivers on proper handling. For example, the selling of defrosted poultry as fresh is a violation of both hygienic and labelling regulations, but the price difference between frozen and fresh fillets may tempt retailers to act inappropriately.

On the other hand, Galli et al. (2018) state that the policies have effectively protected human health, supported the functioning of the internal market, and yielded positive social and economic outcomes. Despite enforcement shortcomings by EU Member States, no major systemic failures attributable to the General Food Law have been identified. Galli et al. (2018) also state that the policies have created a relatively high level of trust in the system, but they cite no study to back up the claim. Sodano et al. (2016) argue that to ensure that the advantages of new technologies outweigh the drawbacks, it is crucial to recognize the underlying political concerns and implement direct regulatory measures, such as *Regulation 2015/2283* regarding novel foods. These may include mandatory labeling and the creation of a public register encompassing products and producers. The European Union should actively adopt new methods, promoting their critical yet essential utilization in food safety assessments as it relates to novel foods (de Boer & Bast, 2018).

1.2 Organic farming

Organic farming involves cultivating crops and rearing animals using natural methods, avoiding the use of synthetic pesticides, fertilizers, and genetically modified organisms (GMOs). It emphasizes the preservation of soil health, biodiversity conservation, and the provision of nutritious, chemical-free food. The importance of organic farming extends beyond individual health benefits, as it addresses global challenges such as biodiversity, water scarcity, climate change, and sustainable soil health.

The embracing of organic farming is motivated by the recognition of the detrimental effects of conventional agricultural practices on human health and the environment. Conventional farming relies on synthetic inputs, such as chemical pesticides and fertilizers, which can accumulate in soil, water, and the food chain, posing risks to human health. It can also lead to soil erosion, water pollution, and the loss of biodiversity. In contrast, organic farming use approaches that reduce these risks and prioritize the long-term well-being of both ecosystems and consumers, reducing air and water pollution and the release of greenhouse gases, and preserving biodiversity.

In the European Union, regulations promoting and regulating organic farming play a vital role. The scope of this report is limited to just two regulations that ensure that organic food is produced according to specific standards and that consumers can make informed choices through clear labeling and identification of organic products.

1.2.1 Label and certification

A. *Introduction*

Commission Regulation (EU) No 203/2012 (Regulation 2012) concerns organic production, labeling, and control. It focuses on organic production and labeling of organic products within the EU and expands upon existing literature (*No 834/2007*) to provide details specifically for organic wine production. The main externality targeted by this policy framework is negative environmental impacts associated with conventional farming practices. By promoting organic farming practices, the policy seeks to reduce the use of synthetic pesticides and fertilizers, protect biodiversity, and improve soil quality. *Regulation (EU) No 1169/2011* (Regulation 2011) establishes the general principles, requirements, and responsibilities governing food information, including food labeling. It applies to all food business operators at all stages of the food chain where their activities concern the provision of food information to consumers. This regulation requires that organic products be labeled as such in accordance with specific rules laid down in *Commission Regulation (EC) No 889/2008,* which includes using an EU organic logo or national organic logo where applicable.

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B. Description of the policies

Regulation (EU) No 203/2012 targets social externalities by promoting sustainable agriculture practices and mitigating negative environmental impacts associated with conventional farming. It targets environmental externalities through reducing the use of synthetic pesticides and fertilizers and enhancing soil quality. By promoting organic farming, the policy framework supports the transition towards more sustainable agricultural practices.

The rationale behind *Regulation (EU) No 1169/2011* is to ensure that consumers have access to accurate and comprehensive information about the food they purchase through the simplification and modernization of existing labeling. Citizens benefit with clear, comprehensible, and legible labeling of foods. The externalities targeted by this policy include public health risks, which are mitigated by providing consumers with information about allergens and nutritional content. In addition, it promotes fair competition among businesses by ensuring consistent labeling standards, and it protects consumer rights by honoring their right to information. The detailed design of this instrument includes a list of mandatory labeling that is required for all foods intended for the final consumer to include ingredients, nutritional content, allergens, origin, and other relevant details on food products.

C. Mechanisms of the instruments for internalization

Commission Regulation (EU) No 203/2012, actively promotes clear labeling of organic products, thus providing consumers with the capacity to make more informed decisions about food purchases and potentially incentivize them to choose more sustainable options. Over time, demand may increase for organic products leading to economies of scale that reduce production costs and make these products more affordable for consumers.

Generally, acknowledging the cost differences between organic and conventional production, the long-term goal of this policy is to promote more sustainable agriculture practices that internalize various externalities along the food value chain. For example, this policy promotes the use of natural inputs, such as compost and manure, instead of synthetic fertilizers and pesticides in (organic) farming practices. This can lead to lower yield and higher input costs for farmers, due to the need for more labor and resources to apply these inputs. However, the input prices may decrease over time as increasing demand for natural inputs leads to economies of scale.

Regulation (EU) No 1169/2011 does not directly change costs or prices to secure or facilitate the internalization of externalities along the food value chains. However, it could indirectly affect costs when food business operators are required to provide clear and accurate information about their products to consumers. This information could change consumers' shopping behavior, which can affect demand for certain products and ultimately prices. Consumers are often willing to pay a premium for a product that is labeled as organic or environmentally friendly (e.g., Peschel et al., 2016; Thøgersen et al., 2019).

The primary targets of this policy are food business operators, at all stages of the food chain, who provide food information to consumers. This includes farmers who produce raw materials, industries that process these raw materials, retailers who sell these products directly to consumers, and restaurants and food services that serve these products to consumers.

D. Policy impacts

Over the past few decades, adjustments have been made to EU legislation concerning food safety, traceability, and food labeling. These changes have been implemented to enhance consumer protection and restore trust in the food system by ensuring greater transparency and accountability. For example, many German retailers have taken additional steps to enhance institutional trust by requesting that their suppliers adhere to private quality and risk management standards, such as IFS or QS (Hartmann, Klink, & Simons, 2015). These standards often surpass legal requirements by a significant margin, further emphasizing their commitment to ensuring high levels of compliance. According to Allena et al. (2017), following the implementation of *Regulation 1169/2011*, which brought significant changes to food information legislation, a coordination issue had emerged between the European Regulation and national provisions. Specifically, questions were raised regarding the applicability of measures and penalties outlined for violations of the Regulation's rules, which could weaken its effectiveness.

Furthermore, it has been debated what role the EU and EU Member States should play in addressing complex issues, such as excessive overweight, and which approaches are more likely to be successful, for example in relation to *Regulation (EU) No. 1169/2011*, which focuses on providing food information to consumers through nutrition declarations and food labeling. Richter (2020) argues that the introduction of mandatory regulation is complicated by unclear effects, while the absence of such regulation further obscures the potential outcomes. A notable challenge with EU law (*Regulation (EU) No 1169/2011*) is that it makes Front-of-Pack (FOP) labeling requirements optional

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for Member States, which is likely to weaken their effect. However, research on the effectiveness of these requirements is still lacking (Richter, 2020).

Labelling of the origin of milk became mandatory as a result of *Regulation 1169/2011* (Marchini et al., 2021). For example, in Italy the local origin of milk is often associated with "local dairies," which holds significant value for Italians (Galli and Brunori 2013; Brunori 2007; Massaglia et al. 2019; Di Vita et al. 2013). Generally, “local” food products are also perceived as synonymous with quality by consumers (Yang and Leung 2019; Ilbery et al. 2005). Other cues to product quality that consumers use include the brand, the packaging, and organic labelling. For example, the declaration of "organic" holds importance for consumers, among other things because it is perceived as representing naturalness and proximity (Merlino et al. 2019). However, both the interest in the "local origin" of food and the focus on "national origin" are important for understanding the impact of EU regulation on the internalization of externalities (cf. Thøgersen & Nohlen 2022).

Pádua et al. (2019) investigated the significant increase in data on the number of reports in the Rapid Alert System for Food and Feed (RASFF) due to *Regulation (EU) No 1169/2011* and whether there is a correlation between the notifications related to food allergens and the entry of this regulation. A total of 627 notifications were recorded, with a significant increase observed after 2015. Cereals and bakery products emerged as the most frequently reported categories, with milk, cereals containing gluten, and eggs identified as the primary allergens. Notifications were primarily based on official market controls and internal checks conducted by companies. The most common actions taken in response to these notifications include product recalls and withdrawal from the market. It was concluded that the rise in notifications since 2015 can be attributed to the influence of *EU Regulation (EU) No 1169/2011* and that there is a need for food allergy education and training within the food industry and food systems.

We have identified little literature on impacts from *Regulations 203/2012.* Esteves, do Amaral Vendramini, & Accioly (2021) published a qualitative meta-synthesis of research on the convergence between organic crop regulations in the United States, Brazil, and Europe. This study aimed to assess the regulations in each country for organic crops related to *Regulation 203/2012*, but it reported no discernable findings, only general reflections on the policies. Overall, it was assessed that a regulatory system should follow global macro trends in the organic market for better supply, and that a single certification system would facilitate greater access to the demand for food. The authors argue for establishing a common, global organic certification.

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Unintended impacts of the regulation

Possible unintended impacts of the regulation are especially understudied. The relevance of this issue is emphasized by Vittuari et al., (2015), who performed a ranking review of EU legislation and policies related to implications on food waste generation and found that of the five legislative acts having the largest negative impacts on food waste, three are among those attributed positive effects on mitigating health risks in this report (*853/2004, 1169/2011, 852/2004*).

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Report on policies with internalised externalities at the EU, national and regional levels

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Food and Nutrition Safety

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Task 2.1 Individual report

Food and Nutrition Security

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Dissemination level	Authors
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1 Contents

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Introduction

Food systems play a critical role in ensuring food security, food safety, and healthy nutrition, which are all vital components that significantly impact population health. Food and nutrition security can be achieved only when all people, at all times, have physical, social and economic access to sufficient, safe (free of contaminants) and nutritious food to meet their dietary needs and food preferences for an active and healthy life (Simelane & Worth, 2020). Based on this definition, food affordability, food safety and nutrition[1], and physical access to food are key dimensions that need to be stable for food security to exist (European Parliament, 2022)[2].

The food system has undergone significant changes since the late 1950s and early 1960s. These changes include an increasing ecological footprint of food, pressure on agriculture, reliance on external resources, corporatization of food production, processing, retailing, and marketing, and a greater role of agro-food science in determining food quality. As a result, the food system has been gradually reshaped, and systemic shocks and stresses have become more frequent, exacerbating existing vulnerabilities and generating new ones. This is evidenced by the continuity of food and nutritional insecurity, global food riots due to food price hikes, food poverty, famines, food-related diseases, and food quality issues. The persistence of these situations have raised questions about the manageability of the current food system and whether it can be redesigned to reduce the size, scale, and intensity of these stressed shocks (Hebinck & Oostindie, 2018).

The European Union (EU) faces concerns regarding food and nutrition security, and it is important to integrate food systems as a key aspect of the EU's bioeconomy (EASAC, 2017). For the second year in a row since Food Insecurity Experience Scale (FIES) data collection began in 2014, the prevalence of severe food insecurity has increased in Europe, which is a region where commonly the lowest rates of food insecurity are observed (FAO, 2022). According to a report released by the World Bank in 2022, the ongoing war in Ukraine has significantly affected the worldwide trade, production, and consumption of commodities. As a result, prices are expected to stay at historically high levels until the end of 2024. This is likely to keep food security as a crucial topic on the EU's agenda for the short-to-medium-term (World Bank Group, 2022).

The FOODCost project examines market failures in the food market, and more precisely externalities. Market failures are situations in which ordinary market coordination does

[1] Food safety focuses on preventing food-borne illnesses, including the proper handling, preparation, and storage of food. Healthy nutrition, on the other hand, concentrates on ensuring that diets have high nutritional value

[2] Food security encompasses not only food safety and healthy nutrition, but also broader concerns such as food availability, access, utilization, and stability.

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not lead to an efficient (perfectly competitive) equilibrium. An externality is a side effect – i.e. an effect outside of any transaction - of one economic agent's actions on another's utility or production level.

Policy instruments may play a major role in securing or facilitating the internalization of externalities along the food value chains. The purpose of Task 2.1. is to review the existing public policies on the scope of externalities and the policy instruments that could be used to address them via different food system actors.

RIVM has completed the database from the scope of the European Union, for **food safety and nutrition related**. The database was constructed with consideration to the **demand side** of these issues.

The main goal is twofold: (i) framing and helping synthetize the mapping and evaluation of policies; (ii) providing a tool for descriptive statistics and creating the timeline of policies (that INRAE will be in charge of).

1 EU Regulatory framework for food safety and nutrition

Key message

The safety of food can be threatened by contamination with micro-organisms and chemical substances. Measures are taken that are necessary to maintain a high level of food safety within the EU. The General Food Law (GFL) lays down the principles of food law, including food safety, traceability, transparency, risk analysis, the precautionary principle as well as the responsibilities of food business operators and competent authorities. These policy instruments of various types play a crucial role in securing the internalization of externalities, primarily those related to health, along the food value chains. Legislation, specifically the food information to consumers regulations, has been created to provide information to consumers about additives, allergens, and other pertinent details when placing foods on the market, with the aim of enabling informed choices.

1.1 Introduction food safety and nutrition EU regulatory framework

Food safety and nutrition are key aspects of food systems. Food safety focuses on preventing food-borne illnesses, including the proper handling, preparation, and storage of food. Food safety is a share responsibility between different stakeholders in the food production chain. Consumers are responsible for food safety in the storage, handling, cooking steps. Healthy nutrition, on the other hand, concentrates on ensuring that foods and diets have sufficient nutritional value, producers supply nutritionally adequate foods, menus and diets, and consumers choose the nutritionally adequate options (Walls et al., 2019).

However, the food system is complex and broad. Commonly, the food chain is described as “from farm to fork”, yet it encompasses more than this. Figure 1 represents a comprehensive framework of the existing legislative framework pertaining to food safety and nutrition in the EU.

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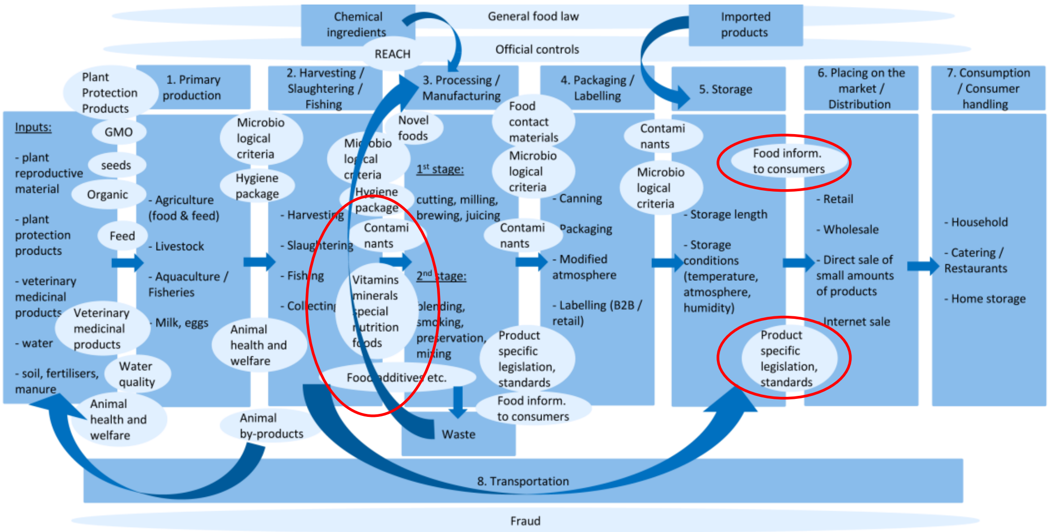

Figure 1 Overview of the food chain system with the major food safety and nutrition legislation fields. Figure retrieved from JRC Science for Policy Report (2016). Delivering on EU Food Safety and Nutrition in 2050 – Future challenges and policy preparedness.

The figure above demonstrates the key legislative areas concerning food safety and nutrition, arranged along the food chain in a way matter that highlights their relevance to the step they precede.

In this report we will be focusing on the following (demarcated by the red circles):

- **Legislation related to the manufacturing step of the food chain**
  - Food improvement agents
  - Contaminants
- **Legislation related to placing foods on the market**
  - Food Information to Consumers (FIC)
  - Nutrition and Health Claims

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2 Food safety

2.1 Introduction

The various food crises that occurred in the EU in the 1990's, including the BSE, commonly referred to as "mad cow disease', drew attention to establish general principles and requirements concerning food and feed law at Union level (Pettoello-Mantovani & Olivieri, 2022). As a reaction, the European Commission (EC) formulated a thorough and unified strategy towards ensuring food safety, known as the "farm to fork "approach primarily delineated in the White Paper on Food Safety (European Commission, 2020b). This approach encompasses all domains of the food chain, including feed production, primary production, food processing, storage, transport, and retail sale[3]. The legislative framework of EU rests upon the fundamental principles of risk analysis, which encompasses risk assessment, risk management, and risk communication (European Commission, 2016a). To ensure the highest level of scientific rigor in risk assessment, the EU relies upon the expertise of the European Food Safety Authority (EFSA). In addition, the precautionary principle is applied in risk management to ensure a proactive and cautious approach to risk mitigation. The regulatory framework thus established prioritizes independence, excellence, and transparency to guarantee the integrity and safety of the food supply for EU citizens (European Commission, 2016a). To facilitate internal trade within the European Union, food safety legislation has been harmonized.

The responsibility for ensuring food safety lies with various stakeholders in both the food and feed chains, with primary responsibility resting with food business operators and manufacturers. Traceability, an important aspect highlighted in the White Paper, has been incorporated into the General Food Law (Regulation (EC) No. 178/2002). The General Food Law Regulation lays down the principles of food law, including food safety, traceability, transparency, risk analysis, and the precautionary principle. It also establishes the responsibilities of food business operators and competent authorities (Regulation (EC) No. 882/2004). It also establishes EFSA, which is responsible for providing independent scientific advice and support to risk managers in the EU. EFSA is responsible for identifying emerging risks and indicating how these should be communicated to the European Parliament, the Commission and the Member States. It also monitors the Rapid Alert System for Food and Feed (RASFF) to provide the Commission and Member States with information for risk analysis. The regulation aims to address the negative externalities of food safety risks, which can have significant impacts on public health, the environment, and the economy. By establishing EFSA and its obligations, the regulation aims to improve food safety and prevent minimize the

[3] Regulation (EC) 178/2002, Article 3(16)

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negative externalities associated with food safety risks. It does so by promoting transparency, communication, and collaboration among different stakeholders in the food supply chain. Specific regulations impose additional requirements on various matters concerning food, including but not limited to food additives, veterinary medicinal products, food hygiene, genetically modified organisms, food contact materials, and food information to consumers.

2.2 Regulatory framework

Economist frequently categorize policy instruments for food safety regulations into three types, namely **mandatory regulations** (command and control, such as input standards, process standards or product-performance standards), **information regulation** (e.g. labelling) and **liability enforcement** (Marette et al., 2003). These different instruments are seen as means to circumvent some market inefficiencies such as informational inefficiencies (e.g. imperfect consumer information on the safety of products, or non-revelation of producer information) and insufficient safety efforts by producers (Marette et al., 2003)[4].

2.2.1 Mandatory regulations

When public health is at stake, command and control instruments are favoured. Food producers are obliged, through various national and European laws, to take measures in order to prevent or limit the occurrence of pathogens and chemical substances in their food products. For pathogens in raw materials and end products microbiological criteria have been set. For chemical substances product limits are applied such as in the field of food improvement agents (food additives, enzymes, and flavourings). For these components it must be demonstrated that at their level of use they do not pose any risk to consumers.

2.2.1.1 Food improvement agents

Food additives, food enzymes and food flavourings are known as “food improvement agents” (European Commission, n.d.-c). These are added to food products for various reasons. For instance, food additives are used to preserve, colour, and stabilize food during the production, packaging, or storage processes. Enzymes, on the other hand, have specific biochemical actions that serve technological purposes at any stage of the food chain. Lastly, flavourings are added to give or alter the odour or taste of food, which can increase the appeal and desirability of the product. By adding these substances, food manufacturers are able to improve the sensory attributes of the product, extend its

[4] According to Marette et al., (2003), command and control as well as informational instruments are more central in the White Paper, and more generally in the EU food-safety regulation, than incentive-based instruments, such as (product-) liability laws. For this reason we exclude the latter from this report.

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shelf life, and ensure safety and quality throughout the food production and supply chain (European Commission, n.d.-c).

The subsequent paragraphs delve into the primary regulations governing food improvement agents within the EU.

Regulation (EC) No 1331/2008 on a common authorisation procedure for food additives, enzymes, and flavourings

Background and rationale. **Regulation (EC) No 1331/2008** lays down a common procedure for the assessment and authorisation of food additives, food enzymes, food flavourings and source materials of food flavourings and of food ingredients with flavouring properties used or intended for use in or on foodstuffs, which contributes to the free movement of food within the Community and to a high level of protection of human health and to a high level of consumer protection, including the protection of consumer interests[5]. Substances that have been approved to be included in the Community list must be published and updated[6]. Either a Community initiative or a request from any Member State or interested party can initiate the standard procedure for updating such list[7]. The Commission may consult EFSA during the procedure. Upon the completion of the common procedure, the Commission adopts a Regulation to implement the update, unless it determines that the update is unwarranted (European Commission, 2016b). In this regulation a comprehensive outline of the necessary steps and timelines, including provisions for urgent situations is provided (European Commission, 2016b). The regulation emphasized transparency in the Authority's operation while also specifying guidelines for protecting the confidentiality of particular data.

In summary, this regulation aims to establish a harmonized and efficient authorisation process for food additives, enzymes, and flavourings in the EU to ensure the safety of consumers and facilitate the free movement of food products within the EU. It also aims to promote transparency in the procedures of the EFSA and to establish a community list of each category of substance following a risk assessment by the EFSA.

Other relevant regulations include:

- **Regulation 234/2011** establishing a common authorisation procedure for food additives, food enzymes and food flavourings

[5] Regulation (EC) No 1331/2008. Chapter I, Article 1 (1)
[6] Regulation (EC) No 1331/2008. Chapter I, Article 2 (1,2)
[7] Regulation (EC) No 1331/2008. Chapter I, Article 4 (1,2)

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Regulation (EC) No 1333/2008 on food additives

Background and rationale. The regulation builds upon previous legislation and takes into account scientific advancements, technological developments, and evolving consumer expectations. Its primary objective is to safeguard consumer health while enabling the use of food additives that are safe and technologically justified.

The Regulation includes provisions for approved lists of food additives, their permitted usage conditions in food or within food additives, food enzymes, and food flavourings, as well as requirements for the labelling of food additives intended for sale. Additionality, it specifies non-additive products and outlines the definition of processing aids. This Regulation employs several command and control instruments to ensure the safety and quality of food additives in the EU. These instruments include the prohibition and restriction of certain food additives that are considered harmful to human health or not necessary for food production. The Regulation also establishes a rigorous approval process for new food additives, which involves safety assessment by EFSA and a review by the EC. Maximum limits of food additives are also set to ensure they are not used excessively, which could pose a risk to human health. Additionally, the regulation requires food additives to be labelled with their name or E-number and function, and provides for monitoring and enforcement mechanisms to ensure compliance, including penalties for non-compliance. On MS level, for example in the Netherlands, the dietary exposure of Dutch consumers to chemical substances allowed by regulating authorities to be used in food production, like additives (the well-known E-numbers) and plant protection products, is low and does not pose a health risk.

Other relevant regulations include:

- **Regulation 234/2011** establishing a common authorisation procedure for food additives, food enzymes and food flavourings
- **Regulation 257/2010** setting up a programme for the re-evaluation of approved food additives

Regulation (EC) No 1332/2008 on food enzymes

Background and rationale. The primary objective of this regulation is to establish rules governing the use of food enzymes in food products, including those utilized as processing aids. It aims to ensure the effective functioning of the internal market whilst ensuring a high level of protection of human health and a high level of consumer protection, including the protection of consumer interests and fair practices in food trade, taking into account, where appropriate, the protection of the environment[8].

[8] Regulation (EC) No 1332/2008. Chapter I, Article 1

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By establishing clear rules and requirements, the regulation ensures that food enzymes are used in a manner that does not pose a risk to human health or mislead consumers. It sets out specific conditions for the authorization, labelling, and use of food enzymes, including provisions for maximum levels, purity criteria, and technological necessity.

Regulation (EC) No 1334/2008 on food flavourings

Background and rationale. Rules on flavourings and food ingredient with properties for use in and on foods are laid down in this regulation. This is in done in view to ensure the effective functioning of the internal market whilst ensuring a high level of protection of human health and a high level of consumer protection, including the protection of consumer interests and fair practices in food trade, taking into account, where appropriate, the protection of the environment[9]

In order to reach these objectives, the regulation provides:

- A Community list of flavourings and source materials approved for use in and on foods;
- Conditions of use of flavourings and food ingredients with flavouring properties in and on foods;
- Rules on the labelling of flavourings.

Definitions are established for various types of flavourings such as natural flavouring substances, flavouring preparations, smoke flavourings, thermal process flavourings, flavour precursors, and other flavourings. It is permissible to use flavourings in food products, provided that they do not pose any safety hazards and their usage does not deceive consumers (European Commission, 2016b).

Other relevant regulations include:

- **Regulation 872/2012** adopting the list of flavouring substances
- **Regulation 873/2013** on transitional measures concerning the Union list of flavourings and source materials set out in Annex I to Regulation 1334/2008
- EU Register of food flavourings

2.2.1.2 Contaminants

Council Regulation (EEC) No 315/93 laying down Community procedures for contaminants in food

Background and rationale**.** This regulation lays down Community procedures for contaminants in food. It seeks to protect public health by prohibiting the marketing of

[9] Regulation (EC) No 1334/2008. Chapter I, Article 1

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foods containing an unacceptable amount of residual substances known as 'contaminants' (European Commission, n.d.-a). Overall, the objective of this regulation is to encompass any substance that is found in food as a consequence of the food's production, processing, preparation, treatment, packaging, transportation, or storage, as well as any substances resulting from environmental contamination. However, extraneous matter that may be present in food is not included within the scope (European Commission, 2016b).

Commission Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs

Background and rationale**.** This regulation lays down the maximum limits for certain food contaminants to protect the health of EU citizens, including the most sensitive population groups, such as children, older people and pregnant women (European Commission, n.d.-d). To safeguard public health, it is crucial to ensure that contaminants remain within toxicologically acceptable levels. While these maximum levels are stringent, they can be attained by following proper practices and considering the risks involved in consuming the food.

The dietary exposure to some chemical substances that occur in the Netherlands through contamination (from the environment, through processing and preparation) exceeds established health-based guidance values. This is the case for three mycotoxins and acrylamide for both children and adults, and for cadmium and lead (heavy metals) for children aged 2-6 years. This exceedance of the health-based guidance value occurs by consumers with a high level of exposure and not with an average exposure. When the exposure to these substances remains too high for a long-standing period, it may be harmful to human health (Mengelers et al., 2017). However, foodborne infections cannot be completely avoided. Food can be contaminated with pathogens at various stages in the food production chain, from raw material up to and including preparation of food. Foodborne diseases are usually caused by bacteria (like Salmonella and Campylobacter), viruses (like Norovirus) and parasites (like Toxoplasma). These pathogens can be found in raw (or not sufficiently heated) animal and plant products. But also people involved in the production of food can cause microbial contamination of our food by inadequate hygiene. Annually, on average, 700,000 cases of foodborne disease were estimated to occur in the Netherlands; this amounts to 1 for every 24 inhabitants. The most important pathogens are Norovirus (mainly found on fish and shellfish), Campylobacter (on chicken) and Salmonella (in eggs). Most illnesses are limited to relatively mild, short-lasting gastrointestinal complaints. Sometimes they can also cause chronic health complaints like reactive arthritis and irritable bowel syndrome (ref how safe is our food).

The effective delivery of safe food through the food chain system relies on the proper implementation of food legislation. To ensure compliance with European regulations,

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Member States have established competent authorities and official controls to monitor and enforce food safety. The Commission is responsible for evaluating the performance of these authorities. Essential risk analysis data, such as surveillance, laboratory analytical results, and epidemiological studies, must be promptly and reliably provided to support decision-making. Continuous monitoring and management of this information facilitate early identification of potential hazards and enable proactive measures to prevent crises. The Food and Veterinary Office, a branch of DG SANTE, monitors and audits the proper functioning of these systems (European Commission, 2016a).

2.2.2 Information regulation

Regulation (EU) 1169/2011 on the provision of food information to consumers is the main law relating to food information in the EU. This Regulation became effective on 12 December 2011 and is applicable since 13 December 2014, with the obligation to provide nutritional information starting from 13 December 2016 (The New Framework Regulation). Any reference made to Directives 2000/13/EC and 90/496/EEC concerning labelling, presentation, advertising, and nutritional labelling for food products are now considered to be references to Regulation 1169/2011 (European Commission, 2016b). The legislation sets forth regulations mandating and permitting food and nutrition information, concerning their composition, computation, articulation, and exhibition. The legislation applies to all stakeholders in the food supply chain, with associated accountabilities established for food business operators at each stage of production and distribution.

Rationale. This Regulation provides the basis for the assurance of a high level of consumer protection in relation to food information, considering the differences in the perception of consumers and their information needs whilst ensuring the smooth functioning of the internal market[10].

Requirements related to food safety. There are several mandatory requirements under this regulation. It is mandatory to: provide origin labelling of unprocessed meat from pigs, sheep, goats and poultry; provide origin labelling of unprocessed meat from pigs, sheep, goats and poultry; highlight allergens in the list of ingredients also for non-pre-packed foods (e.g., sold in restaurants, cafés) and ensure better legibility (e.g., minimum size of text). Other mandatory particulars are: name, list of ingredients, substances causing allergies /intolerances, quantity of certain ingredients or categories of ingredients, net quantity, minimum durability or 'use by' date, special storage conditions and/or conditions of use; details of food business operator or importer, the country of origin or place of provenance for certain types of meat, milk or where its absence might be misleading, instructions for use where appropriate, alcoholic strength by volume (where

[10] Regulation (EU) 1169/2011, Chapter I, Article 1 (1)

they contain more than 1.2 %). These mandatory particulars must be easy to understand, visible and clearly legible (the height of the characters must be at least 1.2 mm). For prepacked foods, this information should appear on the packaging or on the label attached to it. For non-prepacked, this information must be sent to the operators receiving the foodstuffs so that they can provide the information to the end consumer. Certain mandatory particulars can be omitted for some glass bottles, very small packages etc. The operator is responsible for the presence and accuracy of the provided information (European Commission, 2016b).

Various regulations and directives have been established to provide additional information necessary for the implementation of the different provisions of Regulation (EU) No 1169/2011. These regulatory measures encompass specific requirements for the labelling and marketing of diverse products, including those designed for infants and special medical purposes, olive oil, aromatised wine products, fishery, aquaculture, and agricultural products. The related policies are included in Appendix 1.

2.3 Mechanism for internalisation

Key message

Ascertaining the safety of the food supply within a nation is of utmost importance to governments worldwide, as food-borne illnesses resulting from contaminated food can have far-reaching implications. As previously mentioned, governments implement regulations to increase the safety standards of the food supply within a nation, aimed at reducing the occurrence of illnesses resulting from contaminated food (Buzby et al., 1998). Thus, food safety regulations are considered preventive/precautionary in nature since they are designed to internalise the negative externalities associated with food production and consumption. By imposing strict food safety regulations as means to avoid negative externalities, governments places the burden of complying with food regulations on food business operators (FBO), who are responsible for placing products on the market which will not have a negative effect on consumer. Thus, producers operating along the food value chain also make efforts to meet the acceptable hazard levels and minimize the chances of their products being identified as the cause of food-borne illnesses (Ollinger & Nicole, 2003). However, this will come at a cost. On the other hand, by preventing foodborne illnesses, regulations can reduce the incidence of diseases and outbreaks, which can have a positive impact on the health and wellbeing of individuals. Food safety regulations also increase consumer confidence in the food system, which can lead to increased consumption of food products and benefit the food industry. Additionally, by preventing illnesses, these regulations can reduce healthcare costs and improve the productivity of the food industry, which are all positive outcomes (externalities) for society. It is important to note that achieving complete safety is unrealistic. While a zero-risk criterion is suitable in some cases, it may not be feasible in the case microbial pathogens in unprocessed food items (Unnevehr & Jensen, 1996). It

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is improbable that eliminating all pathogens from food will be attainable in the near future. Even if it were possible, it would require extreme measures on a global scale, making food too expensive for the majority of individuals.

Food safety regulations have an impact on households and consumers beyond the public health effects. The implementation of such regulations may alter the pricing, quality, and variety of available products, ultimately affecting the way consumers make decisions about their consumption and overall household welfare (Ragona & Mazzocchi, 2008)

Regulations can increase price by both increasing demand and reducing supply. Food safety is a significant concern for consumers, and food service companies can enhance their credibility and customer loyalty by adhering to prevailing food safety standards (Caswell, 1998). The value of food safety is quantified through a market-based mechanism, which reflects the interaction of supply and demand in determining the value of goods.

However, these effects are not always clear, especially on the demand side. First, food safety cannot be observed or tasted like food quality attributes. Moreover, food safety is frequently regarded as a post-experience food, where it is only after consumption that safety of the product becomes known. As a result, there exists a disparity in information, with consumers often being uninformed about potential food safety hazards. Consequently, it is not evident that consumers would be inclined to pay a premium for food products that possess enhanced safety attributes.

While the expected effects on demand is not always clear, the expected effect of food safety regulations on price via supply is likely to be positive. Applying the number of food safety measures along food value chain, can control potential hazards, but such measures come at a cost, more specifically to (real-resource) compliance cost. These primary fall on FBOs who are responsible for ensuring compliance with EU and national food law (e.g. food and feed safety requirements, labelling requirements), which are relevant to their activities (European Commission, 2018b). These are directs costs that producers face in their efforts to improve food safety, which may involve purchasing new equipment, changing production processes, or investing in employee training (Valeeva, 2005). FBO are likely to reduce supply to offsets these costs.

To illustrate we can use the costs of implementing mandatory labelling. Labelling entails more than just the mere production of the sticker or label indicating for example the origin, allergens or the list of ingredients. This can include different procedures that are required to be fulfilled at various stages of the entire food production chain, which potentially imposes costs on farmers, traders, manufactures and the government (Oh & Ezezika, 2014). Ultimately, as ex ante studies have shown, mandatory labelling will create **additional costs and be passed on to the consumers**. This will most likely depend on the magnitude of industry costs and the elasticity of demand and supply (Golan et al., 2000). The magnitude of these compliance costs can have significant implications for both social welfare and market outcomes. When compliance costs are relatively small, there are likely no significant indirect social welfare losses or transitional costs. However,

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when compliance costs are high, they can have a substantial impact on the affected product markets and must be accounted for in assessments of social **welfare losses and transitional cost** (Valeeva, 2005).

As implementing safety measures is likely to **augment the production costs of food and thus the price**, consumers need to demonstrate a willingness to bear these expenses for food firms to rationalise them. To recover the expenses of ensuring food safety, food firms must be able to generate profits from consumers' enhanced perception of the product's value. Phrased differently, it’s important for producers to know the WTP of consumers in order to see if part of the compliance costs can be deflected to consumers (Gedikoğlu & Gedikoğlu, 2021).Thus, food companies need to ensure that consumers perceive increased value in their products to offset the costs of food safety measures. The sustainability of implemented food safety programs hinges on consumers’ WTP bear the increased cost associated with them. Consumers' acceptance of these increased costs depends on their risk perception regarding food products. For example, a packaging claim highlighting a safety attribute, such as reduced risk of Salmonella, may persuade a consumer to pay an additional $0.50 for a dozen eggs (Hessing et al., 2015). However, not all consumers will consistently select safer food products (Hessing et al., 2015). Certain dietary and personal preferences may lead some consumers to purchase food products that pose a higher health risk, disregarding cost considerations, such as unpasteurized dairy product. Consequently, food companies must produce food products at a level of safety that aligns with an acceptable level of risk, taking into account the balancing act between supply and demand, acceptable risk, and profitability (Hessing et al., 2015). The effectiveness of food safety programs, as highlighted by Henson and Traill (1993), hinges on this delicate balance.

It is important to note that food safety regulations can also affect the final price through various other pathways. For example, food safety regulations could lead to industry profitability due to innovation. The significance of innovative activities undertaken by small and medium-sized enterprises (SMEs) extends beyond their own success and profitability, as they also contribute to the overall economic development. Such enterprises that are innovative exhibit stronger growth and are more likely to gain market share. In the food industry, increased safety standards and the internationalisation of food companies and supermarkets have resulted in price pressures. This has compelled companies to become more efficient and develop novel products (Avermaete et al., 2004). The introduction of innovations in companies, particularly in agriculture, generally leads to an increase in productivity and competitiveness (Sgroi, 2022). This increase can take various forms, including optimized allocation of production factors, diversified production, improved quality of food products, development of products for alternative uses, reduction of indirect costs associated with environmental pollution, and overcoming contextual difficulties arising from specific soil and climatic conditions such as drought, erosion, and salinity (Sgroi, 2022). For example, the adoption of Blockchain technology in the agri-food sector is a digital innovation that seeks to enhance business

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profitability through the **reduction of production inputs** (expressed at constant prices), as well as an **increase in output** (increase in the quantity produced and therefore in revenues expressed at constant prices) (Sgroi, 2022). However, it should be noted that not all areas of operation can benefit equally from innovation and not all innovations are capable of generating increased productivity and competitiveness under certain conditions.

Furthermore, food safety regulations have the potential to incentivize sustainable production practices that reduce the use of for example harmful pesticides and fertilizers, conserve water and energy, and promote biodiversity. Such practices, while ecologically beneficial, may entail higher production costs and consequently **higher prices for consumers**. Additionally, food safety regulations can also encourage sustainable consumption patterns by steering consumers towards safer and healthier food choices. This may create a market demand for sustainably produced food products, which could further incentivize producers to adopt environmentally friendly practices. As a result, food safety regulations may play a vital role in promoting sustainable production and consumption patterns.

2.4 Policy impacts

2.4.1 The REFIT evaluation of the GFL

One of the core objectives of the GFL is to ensure a high level of protection of human health and consumers' interest in relation to food at all times both at EU and national level (European Commission, 2018b). According to European Commission (2018b), the GFL has played a significant role in attaining a notable standard of safeguarding human health. Overall, the GFL has led to safer food in the market.

Effectiveness

In regards to food contaminants and food additives, the monitoring of EU MS has contributed to protecting human health. Data on contaminant levels are used to assess exposure and identify at-risk populations. The EU promotes best practices to minimize contaminant levels in food, and the setting of maximum levels encourage the implementation of preventive measures. Re-evaluation programs have also been initiated for authorised substances in various EU sectorial food legislations, ensuring their safety and conditions of use. This includes the reduction of approved active substances in plant protection products and the evaluation of food additives and flavourings, leading to the withdrawal or amendment of certain substances based on scientific evaluation.

Several factors have not always ensured the full potential of the GFL Regulation to achieve its core objectives. The lengthy authorisation procedures in for food

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improvement agents, health claims etc., can significantly delay the market access process and hinder innovation potential. The duration of these procedures, particularly for innovative products, directly impacts the expected return on investment and lowers the internal rate of return. As a result, the EU food and drink industry's competitiveness is affected limiting its ability to address future challenges and develop innovative products, including those related to food sustainability.

2.4.2 Impact on final quantity produced and consumption

Acquiring evidence regarding the impacts of the chosen food safety policies, namely food improvement agents and contaminants, proved to be difficult. The process of gathering comprehensive and reliable information on these specific subjects encountered challenges stemming from various factors. These included limited research studies, lack of available literature, and the complex and multifaceted nature of the relationship between food safety policies and their impacts.

2.4.1 Impact on health externalities

3 Nutrition

3.1 Introduction

Key message

Mandatory regulations for nutrients contents, labelling and claims for foods and food information to consumers are designed in a similar way as for food safety aspects. Regulations related to (un)healthy foods and diets are under development (e.g. front of pack labelling), voluntary, consists of providing an EU framework or tool to stimulate concerted action among the member states.

The health of the population can improve considerably if people adopt a healthier nutritious diet. If everyone eats enough fruit, vegetables and fish, and not too many saturated fatty acids, average life expectancy could increase by approximately six months. Similar health gains could be made if everyone was a healthy weight. However, only a small section of the population follows the Healthy Dietary Guidelines. Generally, the dietary habits of Europeans are not in line with recommendations for healthy diets (European Commission, 2020a). In 2017, 36% of the EU population did not consumer fruit even once a day or completely avoided it in a typical week, while an equal percentage did not consume vegetables on a daily basis (European Commission, 2019a). The average European individual is likely to consume nearly one kilogram of sugar per month (European Commission, 2018a), and the daily intake of salt in most EU countries ranges from 7-18 grams, surpassing the recommended levels of maximum 5 grams per day. In addition, the intake of saturated fat across 24 European countries generally exceeds the recommended 10% of total energy (%E), with mean intakes varying from 8.9 to 15.5%E. Only two countries[11] have reported intakes below the recommended level of 10%E. Furthermore, the consumption of calorie-dense food, accompanied by the intake of trans-fats and saturated fats, along with the adoption of increasingly sedentary lifestyles, has contributed significantly to the rising rates of obesity in Europe and beyond (WHO Europe, 2022). Over a five-year period from 2014 to 2019, there was a notable upward trend in overweight rates across most EU countries. In the majority of EU MS, the prevalence of overweight and obesity among adult exceeds 50%, further increasing the risk factor for various non-communicable diseases including diabetes, cardiovascular diseases and certain cancers (OECD, n.d.).

In 2007, a comprehensive and coherent Community Strategy was implemented in the field of nutrition to combat the issues of overweight and obesity, and to mitigate the associated risks linked to poor nutrition and insufficient physical activity[12]. This strategy

[11] Finland and Sweden

[12] COM (2007) 279 Final. White paper on strategy for Europe on Nutrition, Overweight and Obesity related health issues

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focused on actions that can be undertaken at various levels, including local, regional, national, and European levels. The implementation of this strategy has influenced a range of EU policies, which aim to improve nutrition by regulating the content and marketing of food products and providing consumers with accurate information, while also ensuring the functioning of the internal market and high levels of consumer protection. This strategy also encompasses policies related to agriculture, transport, information society, education and culture, regional policy, and research.

Additionally, partnerships have been established between Member States, the Commission, the World Health Organization, the public and private sectors, and the food industry to exchange information, agree on common frameworks, commit to shared goals and targets, and introduce voluntary commitments. These integrated, multi-faceted approaches, which involve all segments of society, are considered effective ways to address common EU health challenges because of the complexity and interaction of factors that affect consumers' nutrition and lifestyle behaviours, and ultimately, their health[13]. Finally, the Commission, in collaboration with Member States and the WHO, has established monitoring and reporting mechanisms, utilizing existing national and global indicators and monitoring systems, to evaluate the policies and activities, as well as to monitor and assess the developments in risk factors and health outcomes (European Commission, 2016a).

The establishment of the Consumers Health and Food Executive Agency (CHAFEA) was a significant step taken by the EU to improve food safety and protect the health of its citizens. This was achieved through the Implementation Decision 2013/770/EU, which created CHAFEA as an independent agency responsible for the management of various EU health programmes related to food safety, consumer protection, and health promotion. This is now included in HaDEA (European Health and Digital Executive Agency) as of 2021. HaDEA is responsible for managing a number of EU health programs, including the including the EU4Health program.

More recently, the Farm to Fork Strategy has announced that the Commission will propose a harmonised mandatory front-of-pack nutrition labelling to enable consumers to make informed and health-conscious food choices (European Commission, n.d.-e). The Join Research Centre (JRC) has conducted four scientific studies to synthesize the current evidence on front-of-pack nutrition labelling, origin labelling and food information through other means than on labels. The results of the studies will be utilized in the current and future food information policy-making process. They will contribute to the evidence base that informs the impact assessment for the revision of Regulation EU No 1169/2011 on food information to consumer. Furthermore, the findings will aid in the preparation of the upcoming proposal of the European Commission for a legislative

[13] Council conclusions on nutrition and physical activity. (2014/C 213/01)

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framework for sustainable food systems (FSFS) and for a sustainability labelling framework to inform nutritional, climate, environmental and social aspects of food product (European Commission, 2022).

As the focus of our report is on total populations. Legislation related to food intended for infants and young children, food for special medical purposes, and total diet replacement is excluded from this evaluation as we focus more on population level regulations.

3.2 Regulatory framework

3.2.1 Nutrient sources

The regulation of nutrient sources in the EU plays a critical role in ensuring the safety and efficacy of food products. Nutrients, such as vitamins, minerals, and other substances, are essential for human health and often added to foods and food supplements to address nutritional deficiencies or provide additional health benefits. To maintain a harmonized and standardized approach across member states, the EU has established a comprehensive regulatory framework governing the use of nutrient sources in food products. This regulatory framework includes several regulations and directives that define the permitted nutrient sources, their forms, and the conditions under which they can be added to foods. These regulations aim to safeguard consumer health while promoting innovation and the development of safe and effective food products.

Among the key regulations are **Regulation 1925/2006 on the addition of vitamins and minerals and of certain other substances to foods**. This regulation sets forth guidelines for the use of nutrient sources, ensuring their safety, appropriate levels, and accurate labelling. Another important is Directive 2002/46/EC on the approximation of the laws of the Member States relating to food supplements, which harmonises laws across MS and establishes requirements for composition, labelling, and claims related to nutrient sources in these products.

Other relevant regulations include (EFSA, n.d.):

- **Directive 2006/37/EC** on the inclusion of certain substances;
- **Regulation 1170/2009** of EC on the lists of vitamin and minerals and their forms that can be added to foods, including food supplements;
- **Regulation 1161/2011** on the lists of mineral substances that can be added to foods;
- **Regulation 119/2014** on chromium enriched yeast used for the manufacture of food supplements and chromium(III) lactate tri-hydrate added to foods;
- **Regulation 609/2013** on food intended for infants and young children, food for special medical purposes, and total diet replacement for weight control;

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- **Regulation 953/2009** on substances that may be added for specific nutritional purposes in foods for particular nutritional uses;
- **Regulation 307/2012** on the addition of vitamins and minerals and of certain other substances to foods.

Through these regulatory measures, the EU seeks to protect consumer interests, promote informed choices, and maintain a high level of food safety. By ensuring that nutrient sources are properly regulated, the EU aims to support the development of a diverse and nutritious food supply, contributing to the overall well-being and health of its citizens.

In this context, the EFSA plays a crucial role in evaluating and providing scientific opinions on nutrient sources, contributing to the evidence-based decision-making process within the regulatory framework. By assessing the safety, efficacy, and appropriate use of nutrient sources, EFSA assists in maintaining consumer confidence in the food supply and facilitates innovation in the food industry.

Overall, the regulation of nutrient sources in the EU serves as a cornerstone for promoting public health, ensuring the safety and quality of food products, and facilitating the development of nutritionally sound and beneficial food choices for consumers.

3.2.2 Health and nutrition claims

Health claims associated with functional foods were among the first claims to be used on food labels in the 1980s, but nutrition claims are now more commonly used. Nutrition and health claims are used to highlight specific properties of foods that contain (added or natural) beneficial ingredients or are lower in nutrients we should be eating less of. To maintain consistency and reliability in health-related messaging, the EU has established a robust regulatory framework for the authorisation and use of health and nutrition claims.

One of the key regulations is **Regulation 1924/2006 on nutrition and health claims made on foods**. This regulation provides a standardized framework for nutrition and health claims that apply to all food products intended for final consumers, including those in restaurants, hospitals, and canteens. This regulation prohibits the use of inaccurate, deceptive, or scientifically unsupported information. Any food products that carry a nutrition or health claim must also provide mandatory nutrition labelling, which includes the quantities of energy, fats, carbohydrates, sugars, proteins, and salt. The nutrition labelling aspects are regulated via **Regulation (EU) 1169/2011 on the provision of food information to consumers**, the main law relating to food information in the EU.

There are two categories of claims on foods: 1) Nutrition claims and 2) health claims.

Nutritional claims are defined as claims that refer to what a food contain, for example the contents and comparative claims. Health claims refer to what a food does and refers to general function claims, claims related to a reduction of disease risk, and claims related to the growth and development of children (Collins & Verhagen, 2022). A health claim can be made up from three components: an active ingredient, an effective function, and a health benefit, but one or two of these components is also allowed.

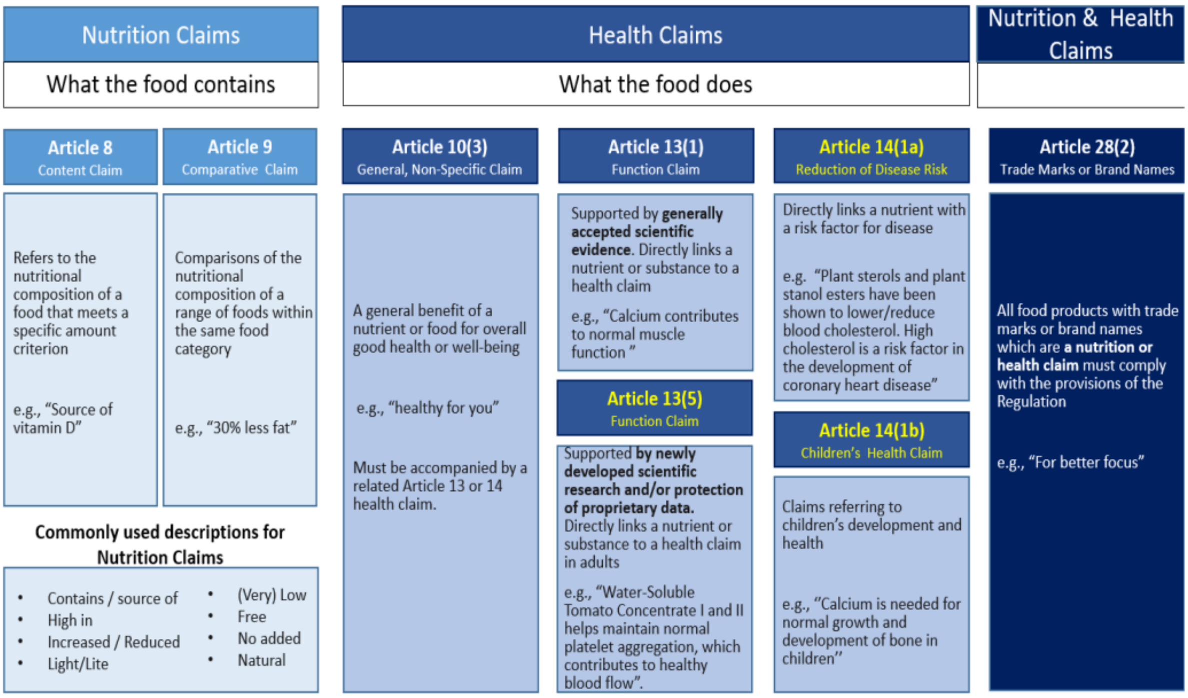

Figure 2 Overview of nutrition and health claims in the EU under Regulation (EC) 1924/2006. Source: Collins et al., (2022)

The primary objective of this regulation is to ensure that claims related to nutrition and health are transparent, based on robust scientific evidence, and enable consumers to make well-informed decisions regarding food products. The EFSA plays a crucial role in evaluating the scientific substantiation of health claims submitted under this regulation. Following the scientific evaluation by EFSA, the European Commission and the Member States hold the authority to decide on the authorization of these claims. Since December 14, 2012, all claims that have not been authorized or are currently under consideration are prohibited. By 2015, EFSA had assessed approximately 3,000 health claim applications. The outcome of this scientific evaluation process revealed that around 250 health claims were evaluated as positive, while a few claims lacked sufficient evidence, and the majority of health claim proposals were deemed unsubstantiated. Most of the approved and authorized health claims pertain to general function claims for vitamins, minerals, and other nutrients. Thus far, EFSA has not found adequate scientific support for any health claim related to microorganisms, with the exception of lactose digestion by yogurt bacteria, and only a limited number of claims concerning "antioxidants."

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In 2012, **EU Regulation 432/2012** established a list of general function claims under Article 13 of Regulation 1924/2006. Simultaneously, the European Commission established the EU Register on nutrition and health claims, which provides a comprehensive overview of all authorized and non-authorized health claims under Articles 13.1, 13.5, and 14 (European Commission, n.d.-b).

Health claims must be accompanied with a statement indicating the importance of a varied diet or the quantity and pattern of consumption which ensures the claimed effect, a statement for those who should avoid using the food, and warning that might bear risks if consumed in excess (article 10). Article 12 of the relevant regulation prohibits claims related to weight loss, disease prevention, treatment or cure, claims targeting specific healthcare professionals, and claims that imply health risks associated with not consuming the food product.

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Box 1

Food labelling in the EU is regulated through the Food Information to Consumers Regulation (EU Regulation 1169/2011). This Regulation provides the basis for the general principles, requirements and responsibilities governing food and nutrition information (food labelling), in order to guarantee the right of consumers to information and reassure the high level of consumer protection. As per this regulation, most food products in the EU are required to have a mandatory back-of-pack nutrition declaration that provides information on the amount of fats, carbohydrates, sugars, protein, and salt in the food.

Food labelling policies have achieved substantial global adoption. The WHO global strategy on diet, physical activity, and health incorporates nutrition labelling. The implementation of food labels and the utilization of nutrition claims can incentivize the industry to enhance the nutritional value of their products through measures such as product improvement, fortification, and food innovation (WHO, 2004).

An increasing number of countries have developed – or are considering guidance on labels with 'interpretative' elements, including rules on nutrient and health claims, rather than just nutrient lists on food packages. Food labels, either at the front or back of the pack, represent a way of communicating nutritional information. This communication on the food may come in three forms: the nutrition labelling, the nutrition logos that are interpretative elements regarding the healthiness of a food, and nutrition and health claims. Labelling can help consumers make informed, healthy and sustainable food choices.

The JRC conducted four scientific studies to synthesise the current evidence on front-of-pack nutrition labelling, origin labelling and food information through other means than on labels as well as to analyse what is currently present on the market as regards the labelling of alcoholic beverages. Evidence on food information – Empowering consumers to make healthy and sustainable choices (europa.eu)

Other relevant regulations include (EFSA, n.d.):

- **Regulation 353/2008** establishing implementing rules for applications for authorisation of health claims;
- **Regulation 1169/2009** establishing implementing rules for applications for authorisation of health claims;
- **Decision 2013/63/EU** adopting guidelines for the implementation of specific conditions for health claims.

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3.2.3 Infant formulae and follow-on formulae

These regulations set specific compositional and information requirements, as well as guidelines on infant and young child feeding practices, to provide a safe and adequate nutritional foundation for this vulnerable population. Two key regulations that govern the production and marketing of infant and follow-on formulae are **Regulation 609/2013 on food intended for infants and young children, food for special medical purposes, and total diet replacement for weight control**, and **Regulation 2016/127** which establishes specific compositional and information requirements for infant formula and follow-on formula, and also includes provisions related to information on infant and young child feeding practices.

These regulations aim to ensure that infant formulae and follow-on formulae meet stringent quality and safety standards, contain appropriate levels of essential nutrients, and provide accurate and comprehensive information for parents and caregivers. By establishing clear guidelines and requirements, the EU regulations strive to protect the health and well-being of infants and young children, while empowering consumers to make informed choices regarding infant feeding practices.

3.2.4 Food allergies & Food for special medical purposes (FSMPs)

Two key regulations that govern the regulation of food allergies and FSMPs in the EU are Regulation EU 1169/2011 on the provision of food information to consumers and Regulation 609/2013 on food intended for infants and young children, food for special medical purposes, and total diet replacement for weight control (explained in the paragraph above).

Regulation EU 1169/2011 focuses on the provision of clear and transparent information to consumers regarding food products, including mandatory allergen labelling to alert individuals with food allergies. This regulation sets guidelines for the labelling, presentation, and advertising of food products, ensuring that consumers are well-informed about the presence of allergenic ingredients. Regulation 609/2013 aims to provide specialized nutrition to infants, young children, and individuals with specific medical conditions who require tailored dietary options. These regulations play a vital role in safeguarding the health and safety of individuals with food allergies and those in need of specialized medical nutrition.

3.2.5 Nutrient contents of foods and labelling

In the European Union, recently adopted Regulation 2019/649 stipulates that industrially produced trans fats in foods intended for final consumption shall not exceed 2g per 100g of fat.

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The regulation is part of the EU's ongoing efforts to improve public health by reducing the consumption of trans fats, which have been linked to an increased risk of heart disease. Trans fats are commonly found in partially hydrogenated vegetable oils, which are used in a wide range of processed foods, such as baked goods, snacks, and fried foods. The WHO has recommended that trans fats be eliminated from the global food supply, and many countries around the world have implemented policies to restrict their use (WHO, 2022). The EU has been at the forefront of these efforts, with several MS, including Denmark being the first country to mandate limits of industrially produced trans-fatty acids (TFA) to 2% of total fat content in all foods in the marketplace, including imported and restaurants (Leth et al., 2006). This dramatically reduced levels of industrially produced TFA in their food supply. Subsequent to that, legislative measures of a similar nature have been implemented in various European nations, such as Austria, Hungary, Iceland, and Norway (WHO, 2022).

The rationale behind the regulation is to protect public health and reduce the incidence of diet-related chronic diseases, such as heart disease and stroke. Trans fats have been identified as a major risk factor for these diseases, and reducing their consumption is seen as a key strategy for improving public health.

3.2.6 Other relevant tools for nutrition policies

3.2.6.1 Front-of-pack nutrition labelling

Front-of-pack nutrition labelling is one of the tools that support the prevention of diet-related, non-communicable diseases like cardiovascular diseases, diabetes or cancers. Under the current EU rules, the provision of nutrition information on the front-of-pack is possible on a voluntary basis, and MS are not permitted to make it mandatory (Gokani, 2022). Since most of the information is displayed at the back of the packaging, it is referred to as BoPNL Numerous studies have indicated that BoPNL is inadequate in assisting consumers with making informed and healthy food choices (Barreiro-Hurlé et al., 2010; Campos et al., 2011; Grunert et al., 2010; Grunert & Wills, 2007). More recently, research has emerged demonstrating that front-of-park nutrition labelling (FoPNL), which present easily understandable nutrition-related information on the front of food packaging, can facilitate consumers in making healthier food choices.

As already mentioned, the EU’s primary intervention to improve consumer food decisions is the requirement in art.9 (1)(1) of Food Information Regulation (FIR) for a nutrition declaration, which has been mandatory for most food products since December 2016. The regulatory process that led to the adoption of the FIR marked the European Union's initial endeavour to explicitly govern front-of-pack nutrition labelling (FoPNL). The impetus for the regulation of FoPNL emerged in response to the growing demand for such information and the emergence of various voluntary labelling schemes in Member

States[14]. This trend was accompanied by the advocacy efforts of consumer protection and public health NGOs, who pushed for a uniform and mandatory FoPNL scheme throughout the EU[15], but this was supported by the Commission in its proposal for the FIR (FIR Proposal)[16]. Despite the Commission's impact assessment acknowledging the superiority of a mandatory scheme in terms of consumer protection and the free movement of goods, it ultimately recommended taking no action or allowing voluntary labelling due to concerns about its potential economic impact on industry.

Despite the lack of mandatory regulations, FoPNL received explicit recognition in the adopted FIR through Article 35. This article allows industry to provide a voluntary form of FoPNL, subject to certain requirements. Additionally, Article 35(2) permits MS to recommend that industry adopt a voluntary FoPNL scheme (Gokani, 2022).

The EC has announced, both in its Farm to Fork Strategy and Europe's Beating Cancer Plan, a proposal for harmonised mandatory FoPNL for the EU.

A recent study on FoPNL conducted by JRC provided more evidence on the importance of FoPNL in the EU:

- Consumers generally value front-of-pack nutrition labels as a quick and easy way to acquire nutrition information when making purchase decisions;
- Less complex labels require less attention and time for consumers to be processed;
- In general, consumers, including consumers with lower income, appear to prefer simple, colourful and evaluative summary front-of-pack labels, which are more easily understood, than more complex, non-evaluative, monochrome labels;
- Front-of-pack nutrition labels can guide consumers towards healthier diets;
- Front-of-pack nutrition labelling seems to provide incentives to food businesses to improve the nutritional quality of their products, such as by reducing added salt or sugars.

3.2.6.2 EU Framework for national initiatives on selected nutrients

Food reformulation initiatives have been recognized as a crucial strategy for enhancing public health outcomes by decreasing the presence of harmful ingredients, such as salt, sugar, and saturated fat, in processed foods to enhance their nutritional value. Even though national and pan-European endeavours have been carried out to combat obesity, it remains a major public health concern, and creating healthy food environments is

[14] European Commission, "Commission Staff Working Document accompanying the Proposal for a Regulation of the European Parliament and of the Council on the provision of food information to consumers: Impact Assessment Report on Nutrition Labelling Issues" COM(2008) 40 final
[15] European Commission, "Commission Staff Working Document accompanying the Proposal for a Regulation of the European Parliament and of the Council on the provision of food information to consumers: Impact Assessment Report on Nutrition Labelling Issues" COM(2008) 40 final
[16] Proposal for a Regulation of the European Parliament and of the Council on the provision of food information to consumers" COM(2008) 40 final

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recognized as a crucial element of obesity prevention (ICF S.A, 2022). Food reformulation initiatives play a crucial role in supporting the EU's Farm to Fork Strategy and promoting sustainable access to nutritious food (ICF S.A, 2022). The Strategy aims to accelerate the transition to a sustainable food system, with a focus on promoting healthy diets (European Commission, 2020a).

Various countries in the EU have adopted different reformulation policies, both mandatory and voluntary, aimed at encouraging food manufacturers to improve the nutritional value of their products. At the EU level, specific mandatory measures have been introduced through legislation. For example, through the provision of food information (Regulation (EU) No 1169/2011), which mandates the declaration of salt content and other nutrient information in prepacked foods. Additionally, a regulation as adopted in April 2019 that sets a legal limit of 2% on industrial trans fats in the total fat content of processed foods (see section 3.2.5). Other EU actions have adopted a voluntary approach to food reformulation. The 2007 White Paper on Nutrition, Overweight and Obesity provided the basis for developing voluntary reformulation approaches across the EU, including reducing levels of 'nutrients of concern' such as fat, saturated and trans fats, salt, and sugar. As a result, the EU Framework for National Salt Initiatives was developed in 2008 to establish a common vision for salt reduction through reformulation. In 2011, the EU Framework for National Initiatives on Selected Nutrients was established, which resulted in the EU Framework for National Initiatives on Fats and Energy focusing on reducing the consumption of fats and sugars (Directorate-General for Health and Food Safety, 2011).

The EU framework for national initiatives on selected nutrients (salt, added sugars and saturated fat) serves as a useful tool to assist MS in designing, implementing, and evaluating reformulation and product improvement strategies in line with their public health policies. The ultimate objective is to reduce the prevalence of overweight and obesity, as well as nutrition-related non-communicable diseases in the general population, with a particular emphasis on children. These initiatives are voluntary and intended for the benefit of MS. MS are encouraged to tailor their initiatives according to national specifications, including targeting other nutrients and food categories, to align with recommended intake levels. Furthermore, reinforcing policies at the MS level could complement and be complemented by stronger concerted action at the EU level (ICF S.A, 2022).

3.2.6.3 EU tool for Public procurement in schools

Procurement mechanisms can be a useful tool to encourage healthier food consumption among schoolchildren, especially given a large share of the total social food service market accounted for by the educational sector (estimated to be around 30% in Europe) (Caldeira Louro et al., 2017). Given that lunch meals can contribute to around 35% of the total daily energy intake (Caldeira Louro et al., 2017), policies aimed at promoting

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healthier eating habits among schoolchildren can not only have positive health outcomes but also potentially enhance academic performance and long-term human capital accumulation. Food companies are not solely motivated by profit, but also consider the wider societal implications of their actions. The procurement of school meals through public channels can encompass the acquisition of raw ingredients that are later prepared on-site in school cafeterias, as well as the outsourcing of food catering services to third-party providers (Caldeira Louro et al., 2017).

Although well-designed procurement programmes have the potential to provide significant benefits, implementing them in practice presents substantial challenges (OECD (2019). For example, translating nutritional guidelines into actionable procurement requirements can be difficult, especially given the need to consider other criteria such as price, quality, non-discrimination, and environmental sustainability when awarding contracts. Monitoring compliance with procurement requirements and evaluating bids can also be time-consuming and expensive. The European Commission has developed a tool to assist schools in drafting better food catering contracts, acknowledging these challenges (European Commission, 2019b). Additionally, gaining the support of chefs and kitchen staff may prove difficult, as they may have differing opinions on the food they prepare. Furthermore, in some cases, mandatory school food standards may be unclear or non-existent (Caldeira Louro et al., 2017).

3.3 The mechanism of externalisation for selected health and nutrition policies

3.3.1 The mechanism of externalisation of food labelling

Nutrition and health regulations have implications for producer costs and consumer prices. First, the financial implications of nutrition and health claims primarily affect companies, particularly food producers, and to a certain extent, food retailers. These costs arise either through internal processes within the company or by outsourcing label-related services. In the table below we illustrate how these regulations can influence the costs borne by producers and the subsequent prices faced by consumers.

	Potential impact on cost of products born by producers	
Printing and design	Negative	Producers will need to get a new label, packaging and potentially invest in new printing methods.
	Neutral	If reformulation can be incorporated into planned rebranding cycles, additional costs can be reduced or eliminated.
Nutritional analysis	Negative	To inform the labelling, products may need to be analysed to determine their nutritional profile.
	Neutral	For some food groups this information is already available.

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Stock write-off	Negative	Existing labels or packaging stock may need to be written off.
Sales	Positive/Negative Variable	Negative labels may decrease sales; while positive labels can increase sales.

Table 1 Potential Impact of labelling on the industry. Source and adapted from: OECD (2019)

Direct costs of designing and printing new labels

The implementation of new FOPNL entails certain costs for food producers. While most OECD countries already require nutritional information from food producers, the need for extensive nutritional analysis is limited. However, producers may need to invest in label redesign and implementation to accommodate the new FOPNL (OECD, 2019). The actual costs are influenced by the implementation period of the policy. If the introduction of the new FOPNL can be synchronised with planned and regular labelling changes, the costs can be significantly lower. The financial impact of label changes may be more significant for smaller businesses that have limited in-house capacity. Furthermore, smaller companies often maintain larger stocks of existing labels or packaging as they order in bulk to take advantage of discounts. Consequently, the duration of the compliance period would impact the costs associated with writing off the existing stock (Centre for International Economics, 2014).

Sales

The impact of front-of-pack labels on product sales is influenced by the specific type of label used. Labels that highlight healthier choices are generally expected to enhance the attractiveness of products to consumers, whereas warning labels on energy-dense products can act as a deterrent (OECD, 2019). A study conducted by Cecchini and Warin (2016) aimed to assess the effectiveness of food labelling in increasing the selection of healthier products and in reducing calorie intake. The results showed that food labelling would increase the amount of people selecting a healthier food product by about 17.95%. Another study conducted by Mørk et al. (2017), focused on a campaign targeting Danish men over the age of 45, aimed at raising awareness and promoting the use of the Keyhole logo. The campaign proved to have had a positive effect on sales of Keyhole-labelled products in two out of three retail chains investigated. The sales increased by about 20% in both retail chains.

These findings underline the efficacy of employing a comprehensive approach that integrates health labels with targeted promotional efforts to drive consumer engagement and stimulate sales of healthier products.

3.3.2 The mechanism of externalisation of reformulation

Labelling requirements laid down in Regulation (EC) No. 1924/2006 might affect the usage of certain ingredients, thereby forcing companies to change their recipe formulations. The consequences of substantially heightening the costs associated with introducing new products to the market would require a substantial increase in both sales and gross profit per product, at least fivefold, or alternatively, a significant rise in prices to achieve the targeted levels of return on investment. Consequently, the outcome would be a market characterized by a reduced number of products being sold at elevated prices compared to the prevailing market conditions (Brookes, 2010). However, the growing media coverage and the heightened media demand for reformulation are anticipated to have a positive impact on nutrition and public health outcomes (Onyeaka et al., 2023). Consequently, reformulation initiatives are pursued to align with evolving consumer preferences and preferences for healthier product options. Moreover, the motivation to engage in reformulation extends to cost reduction and profit maximization objectives, adherence to formal regulatory requirements, and the exploration of new consumer markets as a strategy to counteract declining sales (Fanzo & McLaren, 2020).

Using FoPNL as example, research has shown that it is an effective scheme to encourage the food industry to reformulate their products and develop new and more healthy products (Vyth et al., 2010; Young & Swinburn, 2002). Figure 4 depicts the mechanism through which FOPNL policies affect the consumption of unhealthy products, and in turn, have an impact on the health outcomes of the population.

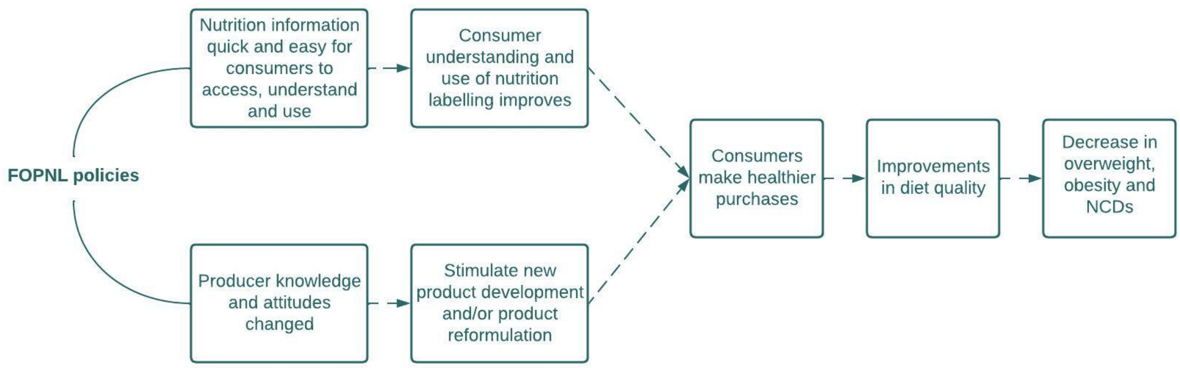

Figure 3 How FOPNL policies work. Adapted from UNICEF (2021)

However, reformulation introduces costs to industry. The profitability of producers can be influenced by product reformulation in several ways, as illustrated in Figure 4. These effects can be observed through fixed, non-recurring costs linked to the development and implementation of the reformulated product, as well as ongoing profit variations arising from potential decreases in sales or increased in production costs.

	Potential impact on cost of products born by producers	
R&D	Negative	Producers may need to invest in research and development to reformulate their products.

	Neutral	If reformulation can be incorporated into planned reformulation cycles, additional costs can be reduced or eliminated.
Marketing	Negative	There may be marketing costs associated with the promotion of the new reformulated product.
	Neutral	If a stealth approach is taken, there will be no marketing costs for the new product.
Sales	Positive/Negative Variable	If the reformulated product is (or is perceived to be) of lower quality, sales may be reduced. However, sales could also be increased if the new product is considered healthier.
Production cost	Positive/Negative Variable	The reformulated product may carry higher or lower ingredient costs, or different production costs.

Table 2 Potential impact of reformulation on the industry. Source and adapted from: OECD (2019)

R&D and marketing

To meet nutrient targets, food companies may need to invest in research to develop healthier products that consumers will accept. However, this process can be complicated since each ingredient can serve multiple functions. The R&D for reformulation involves several steps, including generating ideas, developing the product, evaluating it, testing it with consumers, and studying its shelf life (White et al., 2002).

Once the reformulated product is ready, the changes have to be put into action. Food producers may face various one-time costs during this implementation phase, such as downtime costs when switching production processes, retraining staff, sourcing different materials or ingredients, investing in new machinery and production tools, and marketing the new product (OECD, 2019). The overall cost of R&D depends on the degree of change.

Sales

Reformulation can impact sales either positively or negatively. Negative sales outcomes may arise if the reformulated product is of lower quality or carries a negative perception. Decreasing fat or sugar levels through reformulation can potentially compromise the taste of the product. This may occur due to genuine dislike for the reformulated version or consumer familiarity with higher levels of salt or sugar (OECD, 2019). Reformulation can also influence consumer perception of the product. Making a product healthier through reformulation can enhance its image and appeal to customers. However, the choice of ingredients in the reformulated product may have a negative impact on its image if safety concerns arise or if they are perceived as "unnatural" (WHO, 2017). On the other hand, if the modification is perceived favourably by the general public due to its associated health benefits, marketing strategies can be employed to highlight the novel and improved nature of the healthier product.

Production costs

The financial implications for food producers may vary depending on the nature of product changes, potentially resulting in higher or lower ingredient costs (Buttriss, 2013). For example, engineered salt-replacement products might incur higher costs compared to traditional salt (Wilson, 2013). Conversely, artificial sweeteners may be a more cost-effective option than sugar due to their lower volume requirement to achieve the same level of sweetness (Tandel, 2011). Besides ingredient costs, the reformulated product's distinct characteristics can also influence transport, storage, and packaging expenses (Buttriss, 2013). Both sugar and fat can impact the shelf-life of a product A shorter shelf-life can significantly affect the profitability and efficiency of a company, as it leads to challenges in long-distance transportation, increased restocking costs, higher wastage, and potential consumer aversion (OECD, 2019).

3.3.3 Other mechanisms

Compliance costs

The financial implications of nutrition and health claims primarily affect companies, particularly food producers, and to a certain extent, food retailers. Complying with these regulations may involve investments in equipment, quality control measures, or staff training, which can increase the overall production costs for food producers.

In the case or health claims, the process of scientifically substantiating health claims (articles 13 and 14) poses significant challenges and demands substantial financial and human resources from the food industry to obtain approval from the EFSA. An economic assessment conducted by Brookes (2010), estimated that the endeavour of obtaining approval for health claims in the EU could incur costs ranging from €4.51 to €7.65 million, excluding expenses associated with clinical trials and the provision of proprietary data to support EFSA applications. Costs can also arise from receiving a negative opinion from EFSA. Addressing the concerns raised by EFSA, providing additional evidence, or modifying the claim applications to meet the required scientific standards can require substantial efforts and expenses. Actions can include reformulation of products, label and packaging changes and amending promotional literature, with average costs of about €126,000 (range of €3,000 to €475,000) (Brookes, 2010). Due to a possible negative opinion and subsequent actions needed from the side of the producer, e.g. to reformulate the product, companies perceive that **average prices will increase** (in the short term) since there will be fewer products and less competition in the market[17]. Furthermore, the anticipated elevated costs associated with bringing products to the market will require a strategic approach encompassing both increased average sales volumes and higher prices or profit margins (Brookes, 2010).

[17] The omission of health claims from the labels, promotional materials, and advertising of a product, while other competing products can still employ identical health claims for an extended duration or rely on health claims pending EFSA evaluation, represents the removal of a significant marketing tool and creates obstacles to competitiveness within the marketplace (Brookes, 2010).

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Market competition

In a general sense, the competitiveness of an industry can be characterized by the profitability achieved through its production activities. Specifically, in industries where products lack differentiation, profitability is predominantly influenced by maintaining lower production costs relative to competing firms (Commission of the European Communities, 2008). Nutrition and health regulations can affect market dynamics and competition among producers. For example, the expectations that the costs of bringing new products to market will increase significantly can act as barriers to enter the market, reducing overall competition. In the case of a (possible) mandatory labelling, it is clear that this will impose costs to producers (Rabinovich et al., 2008). The competitive position of small and medium-sized enterprises (SMEs) has emerged as a specific area of concern within this context. Ultimately, it is anticipated that any increases in production costs will be transferred to consumers through higher prices, thus ensuring that the survival of firms is not jeopardized (Rabinovich et al., 2008).

Economies of scale

In the case of mandatory labelling, larger firms are more likely to enjoy economies of scale, which lower the cost-per-unit of complying with regulations (Rabinovich et al., 2008), potentially leading to lower prices for consumers as the market expands.

Consumer demand and behaviours

Nutrition and health regulations may influence consumer behaviour and preferences, thereby affecting demand and prices. For instance, regulations that require clearer nutrition labelling or disclose the presence of certain allergens can help consumers make more informed choices. As consumer demand shifts towards healthier options, producers may respond by offering more of these products, which can lead to increased competition and potentially lower prices for healthier choices.

3.4 Policy impacts

Extensive research and evidence have highlighted the potential impact of nutrition policies on various aspects, including consumer behaviour, public health outcomes, and the food industry. In this section we aim to examine the existing literature and evidence regarding the effects regarding the policy impacts.

3.4.1 The impacts of claims

Health claims have a significant impact on consumption patterns as they influence consumer perceptions, choices, and behaviours regarding food products.

For some consumers, health constitutes a crucial purchasing motive, and the presence of nutrition and health claims has the potential to exert a positive influence on consumer buying behaviour (Food Standards Agency, 2007). Studies conducted in the Netherlands

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(van Kleef & van Trijp, 2005), UK, Italy, Finland & Germany (Daen et al., 2007) have found a high correlation between people's perceived healthiness of products with health claims and their willingness to buy these products. In a study conducted in Finland, Germany, Italy and the UK by Saba et al. (2010), the inclusion of verbal health claims on food products has been observed to have a favourable impact on consumers' perceptions of healthiness and their likelihood to purchase the products. Furthermore, in a study on three different claims (nutrition claim = "Low in fat"; health claim = "With plant sterols. Proven to lower cholesterol"; satiety claim = "Fuller for longer")on four different foods (cereal, soup, lasagne, and yoghurt), Benson et al. (2018) found that claims influenced willingness perceptions of some of the foods included in the study. However, there was little influence of claims on factors for tastiness or healthiness perceptions or portion sizes. However, it is noteworthy that the effects of health-related information on food labels varied across the four countries studied, indicating the importance of considering diverse cultural, traditional, and dietary factors when introducing cereal-based products enriched with beneficial grain compounds to the market. Similar results were observed among Belgium consumers, in which health claims outperformed nutrition claims in terms of perceived convincingness of the claim, credibility of the product, attractiveness of the product, and intention to buy the product (Verbeke et al., 2009).

The impact of claims on public health

Foods with health claims intend to have a positive impact on specific health conditions, however there is a lack of evidence regarding their appeal and usage among the target market that may find them relevant in terms of health benefits (Hung & Verbeke, 2019). In a study conducted by Hung and Verbeke (2019), the use and perception of health claims on food products in 10[18] European countries was examined. The results showed that the association between health claim utilization and its alignment with health relevance exhibited inconsistency. The primary target market, namely consumers who would potentially benefit from the specific health claims, did not consistently engage with or embrace them (Hung & Verbeke, 2019). Still, there was some evidence that individuals with high blood cholesterol or household members with the condition were more likely to use health claims related to cholesterol-lowering effects.

Furthermore, despite the utilization of health claims on food products over the past two decades, there has been no noticeable impact on the occurrence of NCDs related to diet (World Health Organization, 2014). According to Meijer et al. (2022), this lack of impact is unlikely attributed to a scarcity of health claims on food items since about 10% of foods in the EU market carry a health (-related) claim.

[18] United Kingdom, Germany, The Netherlands, Spain, Slovenia, Czechia, France, Denmark, Greece and Lithuania

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3.4.2 The impacts of reformulation

Impact on the promotion of product reformulation and internal market

According to Storcksdieck Genannt Bonsmann et al. (2020), the objective of promoting healthier dietary patterns by regulators can also be accomplished by addressing the food supply side. Producers can be incentivized to adapt the content of their products to the requirements needed to obtain a good nutritional rating. However, this is only possible if FoPNL labels affect consumers' choices (Storcksdieck Genannt Bonsmann et al., 2020).

Reformulation strategies have been formulated in 16 EU countries[19] (as of January 2019)(Kleis et al., 2020). The list of countries can be found in Appendix 3. This has been achieved through the implementation of action plans or agreements targeting multiple nutrients simultaneously, as well as the development of individual measures for various nutrients at different timepoints. A total of sixteen countries have formulated a strategy for reducing salt, 7 countries for reducing sugar, and 7 countries for reducing fats. However, food manufacturing responses to FOP labels are limited, this is especially the case in the EU. In the study by Storcksdieck Genannt Bonsmann et al. (2020), it was concluded that based on the existing evidence, it appears that FoPNL schemes have the potential to stimulate reformulation efforts. However, a more comprehensive and objective dataset is necessary to accurately assess the magnitude of the actual impact. Regarding the impact of FoPNL schemes on the European internal market, no literature was identified that specifically addressed this aspect. Thus, it remains uncertain whether the presence of FoPNL schemes would impede free movement of food products within the internal market.

Impact of food reformulation on health outcomes

A limited amount of studies have looked into the actual impact of reformulation actions implemented by the processed food industry in the EU (Spiteri & Soler, 2018). Most studies have used simulations to assess the potential impact of hypothetical or proposed reformulation actions (Bruins et al., 2015; Dötsch-Klerk et al., 2015; Federici et al., 2019). This is largely due to a general lack of detailed, product/brand-specific, and up-to-date data on processed food composition (Spiteri & Soler, 2018). Moreover, in the current literature, most of the research on food reformulation has been concentrated on examining the effectiveness of sodium reduction measures. However, limited attention has been paid to evaluating the potential health outcomes of reformulation.

3.4.3 A closer look into the impacts FoPNL policies

Over the years, a significant, a significant body of research has been dedicated to investigating the effectiveness, consumer understanding, and impact of various FoPNL

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[19] Austria, Belgium, Bulgaria, France, Greece, Ireland, Italy, Croatia, Luxembourg, Malta, Netherlands, Portugal, Romania, Slovenia and Spain.

schemes. In section X, we address the evidence for topics which have received more attention.

Impact on consumers' preference (WTP)

FoPNL have been the subject of various studies examining their impact on consumers' WTP for labelled food products. These studies aim to understand how the presence of FoPNL influences consumers' purchasing decisions (revealed preferences) and their willingness to spend more money (stated preferences) on labelled food items.

In 2015, a large study was conducted in 16 European countries[20] to investigate the value given by consumers to nutritional label information (Gregori et al., 2015). The distribution of customers' willingness to spend additional money on specifically labelled food varied across different sociodemographic groups. The study found that older age groups (45 years and above) exhibited a positive response to price increases associated with nutritional labelling. Similar effects were observed among respondents from larger families (more than 7 members), those who perceived themselves as obese, and individuals with lower incomes or educational levels. Conversely, higher income levels showed an inverse association with WTP. The study's findings across all countries indicated an average accepted added price of $4.32 to the yearly food expenditure, with a 95% confidence interval of $4.15 to $4.59. Appendix 4 provides a summary of the estimated WTP for each participant country, with Sweden demonstrating the highest WTP ($6.65) and Spain displaying the lowest ($2.33).

Impact on purchases

Scientific studies examining the influence of FoPNL on consumers' decision-making process are relatively scarce. Primarily, these studies encompass field experiments involving real incentives or pre-and post-implementation studies following the introduction of FoPNL regulations. The majority of studies evaluating the effects of FoPNL on consumers' food purchasing decisions employ surveys or experimental methods, focusing on individuals' attention to purchase rather than their actual buying behaviour in response to such labels. Research that examines real-life shopping behaviour in real situations are difficult to implement, thereby limiting its occurrence (Nohlen et al., 2022).

Our focus lies on studies conducted within authentic shopping contexts due to their capacity to provide a heightened level of realism and accommodate a broader range of product variations. This characteristic significantly enhances the generalizability of the findings obtained from such studies. In a review of the scientific literature on the effects of FoPNL (Nohlen et al., 2022), 8 studies using direct observation and real-life data were identified, with 6 of these being conducted in the EU (France, Denmark, Netherlands and the UK).

[20] Austria, Belgium, Denmark, France, Germany, Greece, Italy, The Netherlands, Poland, Portugal, Czech Republic, Slovenia, Spain, Sweden, the United Kingdom, and Hungary

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In France, Dubois et al. (2021) examined whether four pre-selected front-of-pack nutrition labels improved food purchases in real-life grocery shopping settings. 1.9 million labels were put on 1266 food products in four categories (fresh prepared foods, pastries, breads and canned prepared meals) in 60 supermarkets, and the nutritional quality of 1,668,301 purchases was analysed using the Food Standards Agency (FSA) nutrient profiling score. The estimated effect size of FoPNL on the nutrient profiling score of the shopping basket was on average 17 times smaller than those found in comparable laboratory settings. The Nutri-Score, identified as the most effective nutrition label, demonstrated a notable 14% increase in the purchases of foods categorized within the top third of their nutritional quality. However, it did not exert any influence on the purchases of foods categorized as having medium, low, or lacking nutrition labels. Consequently, the Nutri-Score solely improved the nutritional quality of the purchased items within the labelled foods category by a modest 2.5% (equivalent to a reduction of 0.142 FSA points).

In Denmark, Rønnow (2020) investigated the effect of food labels with different formats on dietary quality by using home-scan panel data and difference-in-difference methods to compare the change in dietary quality over time for households that start to use food labels with households that do not use labels. The study showed that the use of FoPNL (Keyhole and the Whole Grain label) improved the overall dietary quality of purchases measured by the Healthy Eating Index (HEI). This was mostly driven by decreased intake of sugar and the increase of intake of fibre, and a non-significant slight increase in fat, although the magnitude of the overall effect was small and marginally significant (Nohlen et al., 2022).

In the Netherlands, Smed et al. (2019) examined the impact of front-of-pack label (Dutch Choices) on actual household purchase patterns. A rise in the market share of products featuring the label was found to correspond with an increase in the volume share of eligible products purchases within the categories of dairy products, yoghurts, and sauces. Notably, minimal or no effect was found in fats and oil categories, as well as for cereals.

In the UK, in terms of the influence of FoPNL on purchased nutrients of concern, there exists evidence from an interrupted time series analysis, specifically a quasi-experimental study. Regarding the impact of FoPNL on purchased nutrients of concerns, there is evidence coming from interrupted time series analysis (a quasi-experimental study based on over 20,000 UK households) suggesting that households responded to the introduction of labelling by reducing the total monthly calories, saturated fatty acid (SFA), sugars, and sodium of store-brand labelled foods by 9–14% on average (Fichera & von Hinke, 2020). Furthermore, Harrington et al. (2019) conducted a pilot randomized controlled trial of a digital behaviour change intervention (Front-of-pack food Labels:

Impact on Consumer Choice (FLICC)). The intervention consisted of a website where participants could access tailored feedback on previous purchases of ready meals and pizzas, set goals for behaviour change, and passive and interactive elements to model behaviour (video demonstrating the behaviour in real store) and (prompt) practice were included for participants to practice the recommended healthy shopping behaviour using traffic light (TL) labels. The results was not able to show differences in the healthiness of purchased ready meals between participants in the intervention group and the control group (both exposed to TL label). This result held during and after the intervention[21].

Overall, while scientific studies on FOPNL's influence on consumer behaviour are limited, the available evidence suggests that these labels can have a positive impact on purchasing behaviours, dietary quality, and nutrient intake, with varying effects across different countries and product categories. Further research is needed to explore the long-term effects and effectiveness of different types of FOPNL in diverse populations and contexts.

Impact on health externalities

In the case of FOPNL implementation, the primary objective is to improve consumers' health, which implies positive health externalities. However, the limited availability of real-life evidence suggests that the assessment of these health externalities is challenging. One can argue that without sufficient empirical data on the direct effects of FoPNL on quantities consumed, it becomes difficult to establish the direct impact of FoPNL nutrition labels on individuals' dietary choices and subsequent health outcomes. However, when there is reliable empirical evidence regarding the impact of food labelling on consumption behaviour, as well as concrete evidence concerning the relationship between dietary intake and health issues (e.g. a reduction in salt intake leading to a decrease in the occurrence of kidney problems), then this provides a high level of evidence.

Impact on health outcomes

In a large multinational observational cohort study, how consumption of foods with high/low Food Standards Agency nutrient profiling system score (FSAm-NPS) relates to cancer risks was characterized in diverse European populations. The study showed that the consumption of food items characterized by a higher FSAm-NPS score (indicating lower nutritional quality) exhibited a heightened association with the risk of cancer. These findings provide substantial support for the applicability and significance of the FSAm-NPS as an underlying nutrient profiling system for FOPNL, as well as for other public health initiatives targeting nutrition (Deschasaux et al., 2018). Furthermore, foods with

[21] Although this study did not yield conclusive findings regarding the influence of the intervention on food purchasing behavior, the authors claim that the distinctive methodologies employed in this pilot trial offer valuable insights for future research endeavors that aim to utilize supermarket loyalty card data in conjunction with collaborative partnerships with supermarkets.

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higher FSAm-NPS score was associated with a higher mortality for all causes and for cancer and diseases of the circulatory, respiratory, and digestive systems (Deschasaux et al., 2020). Based on a macro-simulation conducted using the Preventable Risk Integrated Model (PRIME), the results from Egnell et al. (2019) show that FoPNL can lead to reduction mortality from chronic diseases. Approximately 3.4% of all deaths from diet-related NCDs was estimated to be avoidable when the Nutri-Score FoPNL was used among the French population[22]. The remaining FoPNLs likewise resulted in mortality reduction, although to a lesser extent: Health Star Rating system (2.8%), Reference Intakes (1.9%), Multiple Traffic Lights (1.6%), and SENS (1.1%). In a study conducted in Spain, the association between 5-color Nutri-Score (CNS)-based food consumption and long-term mortality was examined among the adult population. Here the results also showed that the consumption of poor nutritional quality 5-CNS-labeled food products was associated with higher mortality (Donat-Vargas et al., 2021).

Thus, while these studies do demonstrate the efficacy of a healthier diet in reducing morbidity and mortality associated with non-communicable diseases, which is a fundamental principle underlying current dietary guidelines, these studies do not explicitly elucidate the independent contribution of FoPNL towards achieving this desired outcome. Further investigations are warranted to address this knowledge gap; however, conducting such studies poses significant challenges due to their long-term nature, potential methodological limitations, and the presence of numerous confounding factors that may influence the results.

[22] It is important to note that this study had several limitations for the experimental methodology and the PRIME model used which could have influenced the results.

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Appendix 1: Regulations related to FIC

The following Regulations and Directives lay down additional information necessary for the implementation of the different provisions of Regulation (EU) No 1169/2011

1) Commission Regulation (EC) No 589/2008 of 23 June 2008 laying down detailed rules for implementing Council Regulation (EC) No 1234/2007 as regards marketing standards for eggs
2) Regulation (EU) No 1151/2012 of the European Parliament and of the Council of 21 November 2012 on quality schemes for agricultural products and foodstuffs
3) Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91
4) Regulation (EC) No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives (Text with EEA relevance)
5) Regulation (EU) No 1379/2013 of the European Parliament and of the Council of 11 December 2013 on the common organisation of the markets in fishery and aquaculture products, amending Council Regulations (EC) No 1184/2006 and (EC) No 1224/2009 and repealing Council Regulation (EC) No 104/2000
6) Commission Regulation (EC) No 543/2008 of 16 June 2008 laying down detailed rules for the application of Council Regulation (EC) No 1234/2007 as regards the marketing standards for poultry meat
7) Regulation (EC) No 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed
8) Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC
9) Regulation (EC) No 1925/2006 of the European Parliament and of the Council of 20 December 2006 on the addition of vitamins and minerals and of certain other substances to foods
10) Regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods
11) Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007
12) Commission Implementing Regulation (EU) No 543/2011 of 7 June 2011 laying down detailed rules for the application of Council Regulation (EC) No 1234/2007 in respect of the fruit and vegetables and processed fruit and vegetables sectors
13) Regulation (EC) No 110/2008 of the European Parliament and of the Council of 15 January 2008 on the definition, description, presentation, labelling and the protection of geographical indications of spirit drinks and repealing Council Regulation (EEC) No 1576/89

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14) Regulation (EU) No 609/2013 of the European Parliament and of the Council of 12 June 2013 on food intended for infants and young children, food for special medical purposes, and total diet replacement for weight control and repealing Council Directive 92/52/EEC, Commission Directives 96/8/EC, 1999/21/EC, 2006/125/EC and 2006/141/EC, Directive 2009/39/EC of the European Parliament and of the Council and Commission Regulations (EC) No 41/2009 and (EC) No 953/2009
15) Commission Delegated Regulation (EU) 2022/2104 of 29 July 2022 supplementing Regulation (EU) No 1308/2013 of the European Parliament and of the Council as regards marketing standards for olive oil, and repealing Commission Regulation (EEC) No 2568/91 and Commission Implementing Regulation (EU) No 29/2012
16) Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin
17) Directive 2011/91/EU of the European Parliament and of the Council of 13 December 2011 on indications or marks identifying the lot to which a foodstuff belongs (codification)
18) Council Directive 2001/112/EC of 20 December 2001 relating to fruit juices and certain similar products intended for human consumption
19) Council Directive 2001/110/EC of 20 December 2001 relating to honey
20) Council Directive 2001/111/EC of 20 December 2001 relating to certain sugars intended for human consumption
21) Council Directive 2001/113/EC of 20 December 2001 relating to fruit jams, jellies and marmalades and sweetened chestnut purée intended for human consumption
22) Directive 2002/46/EC of the European Parliament and of the Council of 10 June 2002 on the approximation of the laws of the Member States relating to food supplements
23) Commission Delegated Regulation (EU) 2016/127 of 25 September 2015 supplementing Regulation (EU) No 609/2013 of the European Parliament and of the Council as regards the specific compositional and information requirements for infant formula and follow-on formula and as regards requirements on information relating to infant and young child feeding
24) Directive 2009/54/EC of the European Parliament and of the Council of 18 June 2009 on the exploitation and marketing of natural mineral waters
25) Council Directive 2001/114/EC of 20 December 2001 relating to certain partly or wholly dehydrated preserved milk for human consumption
26) Regulation (EU) No 251/2014 of the European Parliament and of the Council of 26 February 2014 on the definition, description, presentation, labelling and the protection of geographical indications of aromatised wine products and repealing Council Regulation (EEC) No 1601/91

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Appendix 2: EU Countries which have implemented reformulation strategies

Country	Defined targets	Strategy
Austria	Salt reduction in baked goods by 15%	Voluntary initiative with industrial bakers
Belgium	10% sugar reduction in soft drinks 8% reduction of added sugar in dairy products 4% sugar reduction in breakfast cereals Total target: reduction of the energy content by 5% Reduction of salt content by 10% in various food groups by 2012 Reduce individual salt intake per person to a maximum 6 g	Voluntary agreement between the Ministry of Health, the Fédération de l'industrie alimentaire belge and the Fédération pour le commerce et les services
Bulgaria	Salt reduction in the food served in school canteens and kindergartens Salt reduction in certain products	Law Mandatory upper limits for salt in the specified products
France	Reduction of salt, sugar and fat	Individual agreements between each voluntarily participating company and the Ministry of Health with specific targets
Greece	Salt reduction	Reduction of the salt content, e.g. in bread Voluntary agreement Initiated by Hellenic Food Authority
Ireland	Reduce salt in processed products	Salt Reduction Programme 2003 initiated by the Food Safety Authority Companies can participate in the programme on a voluntary basis
Italy	Reformulation of foods high in fat, salt and/or sugar Reduce salt content in some baked goods by 10-15%	Voluntary agreements between the Ministry of Health and various companies with different, individual goals Reformulation of products targeted at children
Croatia	Salt reduction in some types of bread by 30% Reduce daily salt intake to 9.3 g per person	Project of the National Institute of Public Health on a voluntary basis with the food industry
Lithuania	Salt reduction by 10% in bread Reduction of sugar in processed foods	Voluntary agreement between the Ministry of Health and various companies Option of a tax (if industry does not comply with the agreement)

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Luxembourg	Reformulate foods high in salt, sugar and/or saturated fats	Voluntary cooperation between the Ministry of Health and the food industry is sought
Malta	Reduce consumption of sugar, salt and saturated fats	Voluntary reformulation measures
Netherlands	Reduce the salt content in products, so that the population intake is limited to a maximum of 6 g salt per person per day Reduce the content of saturated fats in products, so that it is easier for the population to limit consumption to 10% of the daily energy intake Reduce the salt content in bread	Voluntary agreement between the Ministry of Health and industry associations Food reformulation Produce products with lower energy density Improving products targeted at children is a priority Upper limit set by law
Portugal	≤ 1.4 g of salt in 100 g of bread	Law
Romania	Reduce the salt content in processed foods	Cooperation with industry on a voluntary basis
Slovenia	Reduce salt consumption to 5 g per day Reduce consumption of saturated fats by 30%	Voluntary agreement Cooperation between government and industry to enable food reformulation
Spain	Salt reduction Reduce sugar, salt and fat content of food by 10%	Product group-specific targets set by Public Health England Voluntary cooperation with Product-specific: it depends on the product which nutrient is reduced by the formulation Voluntary agreement between the Ministry of Health and the Food and Beverage Industry Association

Table adapted from Kleis et al. (2020)

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Appendix 3: WTP European countries

Table 2. Estimates ($) of the WTP, both Overall and by Country

	ρ	95% Confidence Interval	
Overall	4.35	4.16	4.59
Country			
Sweden	6.65	5.7	9.52
Poland	5.95	4.22	11.97
France	4.78	4.04	5.63
United Kingdom	4.63	3.83	5.66
Germany	4.5	3.89	5.68
Slovenia	4.37	3.59	6.15
Austria	4.3	3.32	6.00
Greece	4.21	3.78	5.18
Italy	4.14	3.53	5.08
Czech Republic	3.63	3.03	4.09
Belgium	3.97	3.01	4.67
Denmark	3.34	2.68	4.74
Portugal	3.26	2.8	4.37
The Netherlands	3.18	2.7	4.63
Hungary	2.46	2.13	2.92
Spain	2.33	2.06	2.80

Table retrieved from Gregori et al. (2015)

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1. Animal welfare

1.1. Introduction

At EU level, animal welfare policies have been developed since the 1970s (Vogeler, 2019). This regulatory framework, considered one of the strictest in the world, is based on the five freedoms that were proposed in 1979 by the UK Farm Animal Welfare Committee; freedom from hunger or thirst, freedom from thermal and physical discomfort, freedom from injury and disease, freedom from fear and chronic stress, freedom to exhibit normal behaviour appropriate to their species (Vogeler, 2019). Similarly, the Lisbon Treaty refers to animals as "sentient beings" and creates an explicit duty for animal welfare under EU law (Gracia, 2013; Vogeler, 2019).

Environmental factors such as temperature and humidity can affect the welfare of production animals on the farm. The progressive increase in temperature caused by climate change has a major impact on animal welfare, especially in livestock production systems in the Mediterranean basin. Similarly, facilities, handling, transport and feeding are factors that affect the health and welfare of farm animals (García-Pérez et al., 2021; Trillo et al., 2017).

Farm animal welfare has been a topic of public debate in several European countries since the mid-1960s (Estévez-Moreno et al., 2021). The intensification of animal production systems in recent years has been criticised and rejected by a large part of society (María, 2006; Miranda-de la Lama et al., 2013). This has led to a growing public interest and awareness of animal welfare on farms. Several studies show that consumers are increasingly interested in the origin of animals, environmentally friendly systems, animal feed and proper handling during transport and slaughter (María, 2006; Miranda-de la Lama et al., 2013; Vogeler, 2019). In Spain there has also been a positive trend in increasing consumer awareness of animal welfare (Estévez-Moreno et al., 2021; García-Pérez et al., 2021; Gracia, 2013).

The social and political importance given to animal welfare varies considerably between countries (Vogeler, 2019). However, increasing global social concern and pressure for animal welfare has influenced the field of agricultural policy with further legislative development for the care of production animals across Europe (Gracia, 2013). Production systems in most European countries have been modified to meet specific requirements (García-Pérez et al., 2021; Gracia, 2013). These requirements are related to the obligation

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to provide more space for animals, to ensure less suffering during their slaughter, to the installation of monitoring systems, among others, which can contribute to improving animal welfare (Vogeler, 2019).

1.2. Animal welfare policies in Spain

For the Spanish government, animal health is a key factor for the development of livestock farming, and of vital importance for both the national economy and public health, as well as for the maintenance and conservation of the diversity of animal species. For public health, because of the possible transmission of diseases from animals to humans and because of the harmful effects that can be caused using certain products to increase animal productivity. For this reason, the Spanish government considers that the basis of good animal health is the existence of an adequate sanitary management of the production sector.

National animal welfare regulations vary considerably from one Member State to another. Spain implements Community legislation on animal welfare throughout the national territory, with the Autonomous Communities being responsible for the application of this legislation in each of their territories. However, following these general guidelines, in recent years Spain has developed more specific regulations for the care of animals during breeding, transport, experimentation and slaughter. Recently (April 2023) the Spanish government updated the Animal Protection and Welfare Code, which aims to compile and organise Spanish legislation on animal protection and welfare (Villalba, 2023). For this thematic area, 15 national policies (decrees, orders and laws) were identified that mainly regulate the following aspects:

- ✓ The management and operation of farms (livestock, pig, rabbit, beekeeping, sheep and goat...).
- ✓ The care of animals, in their exploitation, transport, experimentation and slaughter.
- ✓ Systems for the control of physiological parameters in animals.
- ✓ Products destined for animal feed.
- ✓ General register of livestock movements, general register of livestock holdings and individual identification of animals.
- ✓ Animal health and protection during transport.
- ✓ Control of animal welfare in slaughterhouses through the installation of video-surveillance systems.

- ✓ State subsidies for livestock health defence groups, promotion of indigenous breeds.

More than 50% of these policies have been adopted in the last 10 years. The main economic agents that benefit from these policies are consumers and the community at large. These policies focus mainly on the internalisation of social and environmental externalities. Among the social externalities, as well as having a direct impact on animal welfare, they also have a direct and indirect impact on "Infectious Diseases", "Food Safety" and "Health Effects of Diets". Regarding environmental externalities, these policies have a direct and indirect impact on "Climate Change", "Biodiversity and Ecosystems" and "Land Use and Land Transformation". Similarly, these policies include specific instruments that allow for the internalisation of externalities generated by animal production systems. The main ones are mentioned in the following sections.

1.3. Description of policy instruments

1.3.1. Production Standards (obligations)

Approximately 50% of the policies identified establish specific and/or standardised measures, processes and/or procedures to ensure the proper management and operation of animal production farms. These include location conditions, spaces, types of infrastructure, cleaning and disinfection, types of equipment, types of feed, health and veterinary products, control systems for physiological parameters in animals, among other aspects.

1.3.2. Legal Prescription and Specification

The application of new technologies to reduce production costs and make farms economically viable has led to the concentration of animal populations, increasing the risk of the spread of diseases and "collective pathologies", with greater danger for both animal populations and humans. For this reason, the regulations incorporating this type of instrument aim to control specific aspects such as the correct management of waste, improve the protection of animals at the time of slaughter by installing video surveillance systems to ensure that slaughterhouse workers in contact with live animals comply with regulations designed to maximise animal welfare. The compulsory application of vaccines and treatments and the particular conditions under which such application is to be carried out and the compulsory slaughter of suspect, diseased animals at risk of being affected are also part of the specific regulations included in the legislation.

1.3.3. Bans

The new approaches to sustainable development draw a more complex scenario in which animal production must adapt, implementing better practices and reducing the use of chemical products. This is why the Spanish government has included certain prohibitions mainly related to:

- The entry or exit from the farm or enclosure of vehicles, or restriction, where appropriate, determining the hygienic-sanitary conditions to be met.
- The movement and/or transport of animals and products of animal origin or farm by-products, in certain areas or specific territories of the national territory.
- Temporary prohibition of entry of persons or determination of the relevant hygienic measures necessary to reduce the risk of spread of the pathogen or vector, to which any person entering or leaving the holding or premises must be subjected.
- Use of substances and/or medication for the treatment of diseases and/or vaccination of animals.

1.3.4. Labelling and Packaging

1.3.4.1. Voluntary labelling of "native breed" on products of animal

Native breeds of livestock are subject to special protection not only as part of Spain's animal genetic heritage, but also because they are mostly reared extensively, with the beneficial consequences for the sustainability of the rural environment that this entails. Consumers demand more information on the origin of the products they consume, which is why specific identification by means of a logo is recommended for products from native breeds of animals (Royal Decree 505/2013) (Figure 1).

Figure 1. Labels by species type

1.3.4.2. Voluntary stamp "Certified Welfare Commitment".

In Spain there are own certifications on animal welfare, created by independent reference entities and associations. For example, the "Certified Welfare Commitment" stamp, promoted by Interprofesional del Porcino de Capa Blanca (INTERPORC), emerged in 2019 as a voluntary initiative of the Spanish pork sector and was created by the main production and industrial companies together with a Scientific Committee of high-level experts in animal welfare.

In order to obtain the stamp (figure 2), it is necessary to comply with the requirements of the Interporc Animal Welfare Spain (IAWS) Regulation, which includes those established in EU and national regulations, as well as other more stringent scientific criteria related to animal health and sanitary, biosecurity, animal housing, traceability and the environment.

Figure 2. Certified Welfare Commitment stamp INTERPORC

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1.3.5. Permits, authorisations, communications and registers

The policies that regulate aspects on the exploitation, transport of animals, slaughter and/or killing incorporate obligations related to authorisations, permits, registrations and communications that must be processed and presented by those responsible for the animals and the commercial operators and/or supply and service companies, prior to, at the beginning of the activities and/or during the development of these activities. In some cases, these documents must be submitted by the interested parties annually, monthly and/or as frequently as established by each competent authority. Some of them are:

- Responsible declaration (for entities owning systems for the control of physiological parameters in animals).
- Governmental authorisations for entities holding diagnostic reagents for veterinary use.
- Authorisations and registrations for animal transporters, for animal health products, for the marketing and use of diagnostic reagents for veterinary use.
- General register for holdings, for individual animal identification and general register for monitoring and control of livestock movements.
- Animal movement document/communication (instrument used by farmers and animal keepers for the communication of movements to the competent authority, for the subsequent inclusion of the movements in the General Register of Livestock Movements).

1.3.6. Subsidies

1.3.6.1. Subsidies for the preservation of livestock genetic resources

In Spain, the preservation of livestock genetic resources is of great importance due to the great and varied animal genetic wealth, which has been threatened by the introduction of foreign breeds that have displaced native breeds, to the point of extinction. Among the actions undertaken by the Spanish government with the aim of supporting national animal breeds, there is aid to breeders' organisations or associations officially recognised by the Autonomous Communities, for the conservation of breeds in danger of extinction. The economic support to these entities seeks to ensure that they can continue to perform normally functions that have a clear public, social and economic interest.

1.3.6.2. Subsidies for official breeders' associations

The Spanish government considers that the improvement of sanitary quality, commercial agility and profitability of livestock farms requires a high sanitary level that can only be achieved through the collaboration of the sector, both in the control and eradication of diseases, and in the maintenance and creation of defensive structures against the risk of the appearance and spread of exotic diseases.

1.3.6.3. Subsidies for the slaughter of animals

In case of suspicion of a disease of epizootic character, which by its particular virulence, extreme seriousness or rapid spread implies a potential danger of contagion for the animal population, including domestic or wild animals, or a risk for public health or for the environment, or of any pathological process, the competent authority may adopt, as a precautionary measure, the compulsory slaughter of sick and suspect animals. The Spanish government also provides that the compulsory slaughter of animals shall give rise to the corresponding compensation by the competent authority.

1.4. Mechanisms of the instrument for internalization

1.4.1. Increased production costs and final price of products

Several studies confirm that animal welfare legislation at EU level implies higher economic investments for farmers to comply with stricter and/or additional requirements. Direct policy costs are associated with the overall improvement of management systems, the adoption of more environmentally friendly practices, the expansion and improvement of facilities and/or the appropriate transport of animals, among others. In turn, these high investments to cover direct costs force farmers to increase the price of their products (Bennet et al., 2000; María, 2006; Rayment, Matt, Puja Asthana, Heleen van de Weerd, Jason Gittins, 2010; Van Horne & Achterbosch, 2008; Vogeler, 2019; Winter et al., 1998).

Recent studies have also shown that a large proportion of EU consumers surveyed are willing to pay more for products from production systems that meet higher animal welfare standards (Estévez-Moreno et al., 2021; Rayment, Matt, Puja Asthana, Heleen van de Weerd, Jason Gittins, 2010). Studies in Spain found that between 75% and 87% of respondents (3978 and 335 people) would probably or definitely buy animal welfare friendly meat products, even if it comes at a higher price (Gracia, 2013; María, 2006).

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1.4.2. Labelling mechanisms

1.4.2.1. Price increase if consumers are willing to pay for the label

Some studies emphasise the importance of labelling animal welfare friendly products so that consumers have sufficient information to make informed choices and as a strategy to increase the confidence of those consumers who are willing to pay more for such products (Alonso et al., 2020; Estévez-Moreno et al., 2021; Gracia, 2013; Van Horne & Achterbosch, 2008).

1.4.2.2. Public awareness

A recent study that surveyed 2,433 consumers in four European Union countries, including Spain, found that most respondents (49% of Spaniards) trust that animal welfare labels protect farm animals (Ingenbleek & Krampe, 2022). This study also shows that almost half of the respondents in Spain find labels confusing. One possible explanation is the multiplicity of regional labels and the associated labelling rules that vary according to autonomous legislation. In general, according to the results of this study, Spanish consumers consider the labelling rules to be consistent with the way they would like farm animals to be reared (Ingenbleek & Krampe, 2022).

1.5. Policy impacts

1.5.1. Increased consumer confidence in national products

Estévez-Moreno et al., (2021) analysed meat consumers' attitudes towards farm animal welfare and found that Spanish consumers in general have a high level of confidence in national and European policies and regulations concerning animal welfare. The authors claim that this is one of the main reasons why Spanish consumers prefer domestically produced animal products to imported ones, especially from outside the EU.

1.5.2. Reduced efforts by farmers to prevent animal diseases due to subsidies

Due to the high burden on public sector budgets, it is pertinent to adjust cost-sharing mechanisms in relation to animal diseases. Therefore, one study argues that there is a need for fiscal and non-fiscal intervention policies that promote positive disease risk management practices by farmers (Barnes et al., 2015). The authors of this study point out that public funding is possible to reduce farmers' efforts and reduce overall efficiency, which means that payment rates and eligibility criteria for public funding should be set considering their effect on the incentives faced by livestock farmers (Barnes et al., 2015).

Regarding compensation for compulsory slaughter of animals, economic modelling shows that 100% compensation for slaughtered animals leads to less effort on the farm to prevent diseases than if partial compensation is available. Risk sharing through partial compensation (less than 100%) can induce better biosecurity by farmers (Barnes et al., 2015).

1.5.3. Impacts on externalities

1.5.3.1. Impacts on social externalities

1.5.3.1.1. Animal welfare

(Bennet et al., 2000) assessed the influence of different animal welfare standards on animal welfare in three production systems (dairy, pig, and cage egg production). For this purpose, 80 animal welfare experts were surveyed by Delphi method and scored the importance of the different animal welfare parameters and the influence of the different standards on each parameter. The results show that a higher level of compliance with legal requirements has a more relevant impact on animal welfare on farms.

(Estévez-Moreno et al., 2021) pointed out that new EU animal welfare regulations have significantly improved farm management systems and animal handling, husbandry, transport, and slaughter practices.

1.5.3.1.2. Food Safety and Health effects of diets

Studies show that compliance with higher animal welfare standards is associated with higher quality products. A high percentage of consumers surveyed in different parts of the world, including Spain, say that animal welfare friendly meat products are of higher quality and healthier (Gracia, 2013; María, 2006).

Consumers in Latin American countries consider imported animal products (mainly from European countries) to be of higher quality due to the high regulatory standards they must meet. The increase in demand for this type of product in recent years is associated with a sector of society that is more concerned about healthier eating and disease prevention (Estévez-Moreno et al., 2021)

1.5.3.2. Impacts on economic externalities

1.5.3.2.1. Impacts on market functioning and Spillovers

Some studies conclude that products with higher welfare standards may have greater commercial advantages. Similarly, according to some stakeholders (producer groups and animal welfare groups), differences in animal welfare standards (some stricter than others) and their application can affect production and trade patterns between countries. Especially differences in animal welfare standards between the EU and third countries can influence market conditions and competition between imported products and those of EU producers (Rayment, Matt, Puja Asthana, Heleen van de Weerd, Jason Gittins, 2010).

The development of stricter animal welfare standards between member states and/or variations in the application of the rules makes it necessary to harmonise the rules laid down in legislation to avoid distortions of competition in the internal market (Rayment, Matt, Puja Asthana, Heleen van de Weerd, Jason Gittins, 2010).

1.5.3.3. Impacts on environmental externalities

Animal welfare has served as a focal point for policies that contribute to improving the sustainability of animal production, improving the use of natural resources, enhancing agricultural employment, and maintaining rural livelihoods (Estévez-Moreno et al., 2021).

2. Chemical safety & biosafety

2.1. Integrated Production

The Spanish government defines Integrated Production as: "*agricultural systems for the production of plants that make maximum use of natural resources and production mechanisms and ensure long-term sustainable agriculture, introducing biological and chemical control methods and other techniques that reconcile the demands of society, environmental protection and agricultural productivity, as well as the operations carried out for the handling, packaging, processing and labelling of plant products covered by the system"* (Vicente Aparicio Salmerón et al., 2010).

2.1.1. Integrated Production Policies in Spain

In Spain, the Integrated Production of agricultural products is regulated by Royal Decree 1201/2002, of 20 November 2002, which aims to establish the production rules and general requirements to be fulfilled by the operators that apply integrated production systems. It establishes for each phase of the production cycle, the practices considered obligatory and those that are expressly prohibited.

This decree states that specific technical regulations must be developed for each crop or group of crops. This is why specific technical standards have been developed for horticultural crops, citrus fruits, olive grove, garlic, cotton and sugar beet. These crop-specific technical standards usually include two main aspects: agronomic practices (mandatory, recommended and prohibited practices) and integrated control strategies. This royal decree and the technical regulations focus mainly on the internalisation of social and environmental externalities.

2.1.2. Description of policy instruments

2.1.2.1. Production Standards

This decree establishes mandatory and probihibited measures about: general agronomic aspects, soil, land preparation and tillage, sowing/planting, fertilisation, and amendments, pruning, irrigation, integrated control, harvesting, post-harvest, treatments, preservation, storage, and packaging.

2.1.2.2. Bans

Some of the main bans are related to:

- Soil disinfection by chemical treatments.
- Nitric nitrogen applications on the margins of plots bordering watercourses.
- In horticultural crops, use of herbicides inside the greenhouse once the crop has been planted.
- Use of residual herbicides on sandy soils.
- The use of non-selective, long persistent, highly volatile, leachable or other negative plant protection products.
- The use of plant protection products on the banks of watercourses.
- The use of synthetic chemical products to control pests and parasites.
- The abandonment of plastic waste, containers and other waste inside or at the edge of the plot.
- The burning of plant residues, except when expressly recommended by the competent authority.

2.1.2.3. Certification and labelling instrument

2.1.2.3.1. Integrated Production Identification for Industries

This Royal Decree and its specific technical regulations establish the use of integrated production guarantee identifications, which differentiate the products obtained through integrated production systems. The proposed Quality System entails certification by certification institutions of agri-food products with specific standards and techniques that differentiate the product obtained and allow for its traceability. This allows consumers to know how the product is obtained and its origin. In Spain there are several types of labels depending on the type of agricultural sector and the Autonomous Communities (figure 3).

National guarantee label

Autonomous Community labels

Figure 3. Types of Integrated Production labels in Spain.

2.1.3. Mechanisms of the instrument for internalization

2.1.3.1. Impact on production costs

Some studies show that, although integrated production systems bring savings due to the reduction of phytosanitary treatments, in general production costs are higher than in conventional systems. This is mainly due to the costs of the specific materials required for integrated production (Ascensión Hinojosa-Rodriguez et al., 2014; García González De Lena & Isabel Feito Díaz, 2005). However, Metzidakis et al., (2008) point out that the application of integrated production in the short term will help to reduce resource wastage and production costs. These reductions are derived from the input of chemicals can be adjusted to the needs of the crop through pest monitoring and soil and leaf analysis.

2.1.3.2. Impact on the price of products

One of the main principles of integrated production is the implementation of more environmentally friendly practices, which leads to higher prices and better sales than products from intensive conventional agriculture (Metzidakis et al., 2008).

2.1.3.3. Impact on chemical input

Integrated production systems require lower doses of fertilisers and pesticides due to the implementation of better practices for biological pest control and soil management. The application of phytosanitary treatments is more rational from an agronomic and environmental perspective, as this is done to a greater extent only when the infestation exceeds a certain level or in response to expert advice (Hinojosa-Rodríguez et al., 2014;

Romero-Gámez et al., 2017). In integrated crop production systems, residues such as livestock manure are added to the cropland, thus replacing part of the chemical fertiliser inputs (Hendrickson et al., 2008).

2.1.3.4. Public awareness

A study analysing intensive olive production systems suggests that agri-environmental measures and subsidies for sustainable farming systems, such as integrated production, could help raise public awareness and encourage the production of safe, environmentally and resource-friendly food (Metzidakis et al., 2008).

2.1.3.5. Labelling mechanisms

2.1.3.5.1. Impact on the final price of labelled products

Products derived from olives grown under integrated production systems can fetch higher prices after they have been properly packaged and labelled by a certification institution that has guaranteed their quality and safety (Metzidakis et al., 2008).

2.1.4. Policy impacts

Integrated Production is relevant for many productive sectors in Spain. The adoption of this type of production system has had an increasing trend in recent years. The Integrated Production Certified Quality System is supported by the Royal Decree 1201/2002 and the specific technical regulations that promote the certification of product quality following the implementation of a set of agricultural practices designed to be more sustainable, profitable, fair for farmers and beneficial for the health of consumers (Ascensión Hinojosa-Rodriguez et al., 2014; Vicente Aparicio Salmerón et al., 2010).

2.1.4.1. Improved verification of compliance with regulatory standards

There are difficulties/limitations on the part of public administrations to check compliance with the practices to be implemented in integrated production systems. In this sense, the certification systems by means of which independent certification institutions obtain identification and guarantee marks for the products contribute to guaranteeing compliance with the production standards and general requirements that operators must comply with (Gómez-Limón & Arriaza Balmón, 2011).

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2.1.4.2. Impacts on externalities

Through Integrated Production it is possible to introduce "extrinsic" qualities into the products or raw materials, such as the conservation of biodiversity. This is mainly through the control of production processes (Ascensión Hinojosa-Rodriguez et al., 2014).

2.1.4.2.1. Impacts on environmental externalities

Multifunctional and comparative analyses of integrated and conventional production systems show that in the case of olive cultivation under integrated production (in Andalusia - Spain), a more rational use of irrigation water is achieved. This type of system also contributes to the maintenance of biodiversity, conservation of natural resources and the reduction of air and water pollution (Ascensión Hinojosa-Rodriguez et al., 2014; Gómez-Limón & Arriaza Balmón, 2011; Parra López et al., 2004). In olive growing systems, integrated production seems to be one of the best alternatives against soil erosion, according to the results of sensitivity analyses carried out in previous studies (Parra-López et al., 2007).

(Javier Calatrava Requena, 1999) analysed the incidence of the characteristics of integrated production on the Total Economic Value (TEV), considering the production value and the value of environmental conservation. Regarding the latter factor, he indicated that, in the case of olive oil obtained through integrated production, the TEV is probably higher than that of conventional production. This is mainly because integrated production guarantees better conservation of soil structure, erosion control, reduction of pesticides and in general a lower environmental impact. On the other hand, he pointed out that these benefits from an environmental point of view also have a positive impact on the conservation of the patrimony of olive cultivation (Javier Calatrava Requena, 1999).

Analyses in regions such as Almeria in Spain show better phytosanitary balances in integrated production systems. The inclusion of biological control is effective for pest control and helps to reduce the use of chemicals and in turn residues (Vicente Aparicio Salmerón et al., 2010). Other study also highlights that integrated farming provides adequate production and minimises negative environmental impact (reduction of waste, erosion and soil contamination, etc.) (Metzidakis et al., 2008).

2.1.4.2.2. Impacts on social externalities

2.1.4.2.2.1. Food Safety

Integrated production contributes to residue-free food production thanks to the reduction of phytosanitary products through the implementation of biological control as a priority practice. This type of production system helps to improve the quality of production and to reduce bad practices and improper use of chemical products, which gives more confidence to the actors involved in the production system (Vicente Aparicio Salmerón et al., 2010).

Some companies consider that labels are essential to make visible the characteristics that differentiate products and for these attributes to be identified and valued by consumers. A study that analysed the interpretation of integrated production labels by Spanish consumers (30 respondents) found that although most consumers were not very familiar with this label, they considered it to be a guarantee of product safety and quality (Lozano et al., 2012).

2.1.4.2.3. Impacts on economic externalities

2.1.4.2.3.1. Impacts on market functioning and Spillovers

One of the advantages that organised groups of farmers producing under integrated production have is access to niche and export markets and enjoy a profit margin similar to that of organic farmers (Metzidakis et al., 2008).

2.2. Food Safety

2.2.1. Food safety policies in Spain

Several studies show that the food crises and major changes in the Spanish food supply system have increased food safety concerns among Spanish consumers and retailers (Radwan et al., 2009; Sans et al., 2005; Scarpato et al., 2017). This is one of the main reasons why governments have raised health quality standards and intensified controls along the food chain. This has also led food companies to continually review their own marketing strategies to gain consumer confidence (Isanta-Muñoz et al., 2020; Sans et al., 2005; Scarpato et al., 2017).

Part of the regulatory framework related to food safety aims to ensure that authorities have complete and accurate information about market developments, from the producer to the final distributor. This is why in some sectors, such as the dairy sector, obligations have been extended, such as the declarations to be made by manufacturers of liquid packaged cow's milk. The aim is to ensure traceability and transparency at all stages of the food chain.

The National Programme for the Official Control of the Hygienic-Sanitary Conditions of the Production and Traceability of Raw Milk from Cows, Sheep and Goats has as its main objective the protection of public health as well as the interests of consumers, guaranteeing at all times compliance with the rules relating to the production of raw milk from cows, sheep and goats and ensuring the traceability of the milk from the farm to the production line.

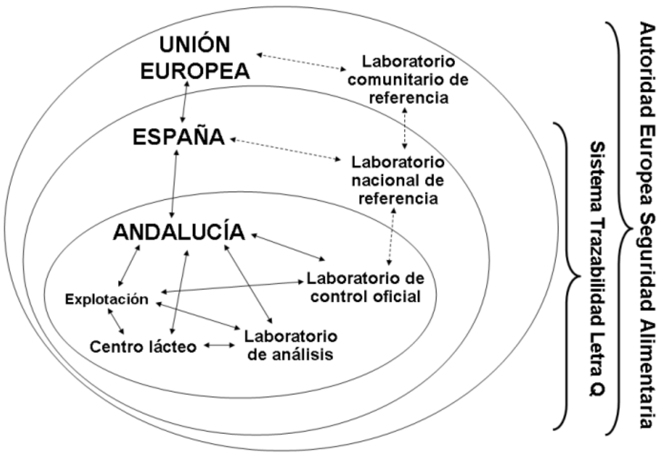

Figure 4. Flowchart of the traceability system for milk in Spain
(Fernando Isanta Muñoz, 2019)

The "Letra Q database" (Raw cow's milk, traceability and quality - Royal Decree 989/2022) was created by the Ministry of Agriculture, Fisheries and Food as a tool to ensure the hygienic-sanitary quality and traceability of raw milk up to the first unloading. This database is the support for the general register of agents and containers of the dairy sector and contains all the information related to the hygienic-sanitary quality and traceability of raw milk up to the first discharge (Figure 4).

On the other hand, biosecurity has become one of the central health issues. For the Spanish government, investment in biosecurity contributes to strengthening the livestock sector as a whole by increasing the confidence of trading partners, allowing higher production and improved sanitary quality of production, reducing the risk of diseases entering farms, and reducing their capacity to spread. Cleaning and disinfection are considered a fundamental pillar of biosecurity measures, so it is essential to have accessible, modern and equipped cleaning and disinfection centres.

Some of the aid earmarked by the government to improve food safety is part of the Plan for the Recovery, Transformation and Resilience of the Spanish Economy, corresponding to Investment 3 (Plan to boost the sustainability and competitiveness of agriculture and livestock (II): Strengthening of training and biosafety systems in nurseries and cleaning and disinfection centres).

Law 12/2013 regulates measures to improve the functioning of the food supply chain. Its main purpose is to improve the functioning and structuring of the food supply chain so as to increase the efficiency and competitiveness of the Spanish agri-food sector and reduce the imbalance in commercial relations between the different operators in the value chain, within the framework of fair competition that benefits not only the sector, but also consumers. It also seeks to contribute to guaranteeing consumer rights in terms of improving comprehensive and effective information on food and food quality, transparency in the functioning of the supply chain, as well as the availability of sufficient and quality food.

By Resolution of 10 December 2015, the Spanish government issued the Code of Good Commercial Practices in Food Procurement. This code includes aspects related to food safety, quality and consumer information. Product quality is an objective shared by all participants in the supply chain. To this end, operators shall co-operate in its assurance. Operators, as well as their associations or member organisations, must commit themselves to co-operate on food safety.

2.2.2. Description of policy instruments

2.2.2.1. Legal prescription and specification

2.2.2.1.1. Mandatory monthly declarations and contracts

Decree 153/2016 and Decree 319/2015 regulate the mandatory declarations to be made by manufacturers, first purchasers and producers of milk and dairy products. These decrees establish a system of monthly declarations and mandatory written contracts

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between first purchasers and producers in the dairy sector. This provides transparency for the first links in the sector.

2.2.2.1.2. General register of operators in the milk sector and communication of milk movements

Royal Decree 989/2022 lays down the basic rules for the registration of operators in the dairy sector, milk movements and control at the level of primary production and up to the first unloading. This decree establishes:

- The identification and registration of agents producing, transporting, collecting or keeping raw milk produced and collected directly from farms, as well as all containers, whether tanks or cisterns, used until arrival at the dairy center.
- The registration of movements of raw milk (in the **"Letra Q database")** between registered agents and containers, as well as the rejection of milk if it is unfit for consumption.
- The minimum controls to be carried out on a compulsory basis by operators in the dairy sector to ensure that the holding complies with the hygiene and health requirements for milk production.
- The conditions under which samples of raw milk from farm tanks and milk transport tankers must be taken, transported and analysed.
- The conditions to be met by laboratories for the analysis of raw milk samples in order to comply with the control system.
- The basis for carrying out official controls in the field of hygienic and sanitary quality requirements for raw milk.
- The records and information for the identification and recording of the results of raw milk samples taken from farm tanks and milk transport tanks, to be included in the "Letra Q database".

2.2.2.1.3. Technical specifications for transport vehicles

Royal Decree 237/2000 establishes the technical specifications to be met by special vehicles for the land transport of foodstuffs. The decree also stipulates that vehicles must have a certificate of conformity and undergo periodic inspections.

2.2.2.1.4. Hygiene requirements for the production and marketing of foodstuffs in retail establishments

Royal Decree 1021/2022 lays down the hygiene requirements for the production and marketing of foodstuffs in retail establishments. This decree establishes among other things

- The temperatures at which food must be kept in retail establishments.
- Specific requirements for the preparation of fresh meat and meat products.
- Requirements on the display for the sale of fishery products and for the identification and information of consumers.
- Specific requirements for other forms of marketing of products such as tasting areas, vending machines and on-premises food processing.
- Requirements for traditional production methods.

Foral Law 17/2001 establishes the obligations for retail commercial activities in Navarre. Decree 32/2003 of 30 April 2003 lays down the obligations for restaurant activities.

2.2.2.2. Subsidies

2.2.2.2.1. Subsidies for biosafety investments

Royal Decree 949/2021 regulates subsidies for investments in biosecurity for the improvement of centres for cleaning and disinfection of livestock road transport vehicles, or for the construction of new centres for this purpose.

2.2.2.2.2. Subsidies for technical assistance schemes in the agri-food sectors

Order APA/925/2007, which regulates subsidies aimed at improving adequate consumer information on the production systems for agri-food products. They also support the implementation of quality management systems, certification and environmental audits.

2.2.2.2.3. Subsidies for the implementation of self-monitoring systems in livestock markets

Royal Decree 190/2007 regulates aid for the implementation of self-monitoring systems in livestock markets, understood as the implementation and development of a protocol of actions, which with a prior and preventive character. This type of system allows a more detailed control of the different stages, achieving a better use of its resources and therefore providing a quicker and more effective response to possible eventualities that may affect the achievement of the established objectives of health, welfare, identification and traceability of livestock.

2.2.3. Mechanisms of the instrument for internalization

2.2.3.1. Impact on the price of products

Price is an important indicator of food quality (Scarpato et al., 2017). Traill & Koenig, (2010) shows that the additional cost per unit to reach higher and higher levels of safety is an increasing function. Improving safety from a very low level is easier and cheaper. However, additional improvements in product safety are increasingly costly (figure 5).

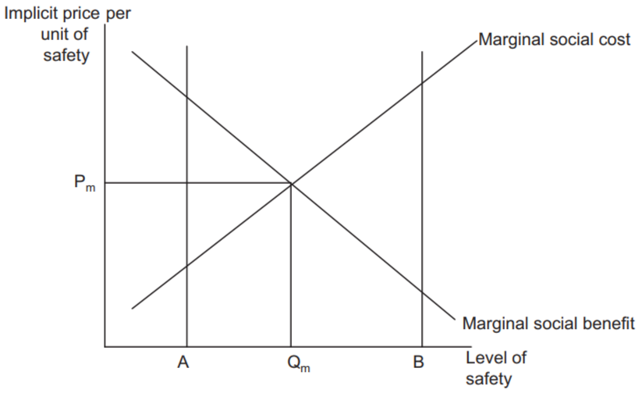

Figure 5. Demand for and supply of food Safety (Traill & Koenig, 2010)

Companies that decide to improve the safety of their products have to bear the increased costs due to higher requirements for traceability, inspection, control, reorganisation of production, labelling, etc. Some of these costs may be passed on to consumers in the form of higher prices, so the cost burden is shared between producers and consumers (Sans et al., 2005; Traill & Koenig, 2010).

2.2.3.2. Impact on public awareness and consumption purchases

In recent years, food safety has become more relevant in public debate and food policy, which has contributed to a growing awareness in the food industry that competing on price alone is not the best business strategy. Similarly, there is now a relatively high level of public awareness of the importance of food safety. It is a criterion that influences the choice of food that is purchased by Spanish consumers (Scarpato et al., 2017). In fact, customer pressure is one of the main factors why companies implement private certifications after they have already complied with legal regulations (Hernández-Rubio et al., 2018).

Society's additional willingness to pay to avoid ill-health, and the costs of treating ill-health (social marginal benefits), decrease as the level of safety increases. If food is very unsafe more people would be willing to pay for a small increase in safety, but once food is already relatively safe, people are less willing to pay for improvements (Traill & Koenig, 2010). Pouliot & Sumner points out (2008) that improved traceability processes provide greater assurance of food safety and this in turn increases consumers' willingness to pay for the (safer) product. Wongprawmas & Canavari (2017) points out that some consumers are willing to pay between 50 and 60% more than conventional prices for vegetables without residues and safe vegetables. The results of the study by Sans et al, (2005) also show that 72% of Spaniards surveyed are not willing to pay a price premium, however low, as a guarantee of meat quality.

2.2.3.3. Labelling mechanisms

2.2.3.3.1. Impact on the market and Public awareness

Labels are one of the main sources of information for consumers, through them they can know aspects such as the quality and safety of food before consuming it (Traill & Koenig, 2010). Food safety labels based on a reliable and properly enforced quality assurance system are socially desirable. This makes it possible to reduce the asymmetry of information between the seller and the consumers and reduce the search time. That is why several studies indicate that consumers are willing to pay a higher price for safer (certified) products and food safety labels (Wongprawmas & Canavari, 2017). Angulo et al., (2005) assessed the value of quality and safety for beef consumers in Spain according to the willingness to pay a premium for labelled beef. The analysis results show that the majority of consumers surveyed are not willing to pay a premium for labelled beef.

Food safety levels differ across the industry, for example in the transformation period of emerging markets the baseline level of food safety is not as high as it could be because they are not prepared to upgrade their resources and technology to meet very high standards. However, the strategy of introducing standards and labels seems appropriate in emerging markets (Wongprawmas & Canavari, 2017).

2.2.4. Policy impacts

Food safety regulation is incremental, and companies also benefit from these regulations because such standards are essential for markets to function effectively and to ensure that companies operate profitably (Traill & Koenig, 2010).

Regulations that make traceability and labeling mandatory in Spain (for example, traceability systems for the beef supply chain) give Spanish consumers more credibility and give more importance to this traceability system. The traceability information on the label in text form is well accepted by Spanish consumers (Magalhaes et al., 2021).

2.2.5. Impacts on externalities

2.2.5.1. Impacts on social externalities

2.2.5.1.1. Food Safety

According to Isanta-Muñoz et al, (2020) the LeTrA Q traceability system for raw goat's milk works well and generates dynamic and fluid information, which contributes to guaranteeing food safety for consumers on the part of public administrations. In the Autonomous Community of Andalusia, the correct functioning of the LeTrA Q traceability system improves consumer food safety and constitutes a valuable tool for improving the technical and economic management of farms (Isanta-Muñoz et al., 2020).

2.2.5.1.2. Consumer Rights

The strategy of labelling with details of any quality certification helps to reduce information asymmetries between the producer and the consumer about the safety and quality attributes of the product (Scarpato et al., 2017).

2.2.5.2. Impacts on economic externalities

2.2.5.2.1. Impacts on market functioning and Spillovers

The LeTrA Q traceability system is a very useful tool for the management and improvement of information standards and business knowledge in the producing and processing sector (Isanta-Muñoz et al., 2020).

FOOD COST Redefining the value of food

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3. Food security & nutrition

3.1. Nutrition

3.1.1. Introduction

The 2008 financial crisis in Spain increased the consumption of food of low nutritional value such as desserts and other sugary foods, decreasing the consumption of products such as fruit, vegetables, meat, and fish. In 2017, 27% of the adult population in Spain recognised that they consumed insufficient fruit and vegetables. For more than two decades the figures for childhood overweight and obesity in Spain have increased and are currently among the highest in Europe. In 2016, 41% of the population aged 6 to 9 was overweight (23%) or obese (17%) (Gobierno de España - Ministerio de Sanidad, 2022; Instituto Nacional de Estadística, 2022). Obesity implies costs in terms of health care expenditure which in the case of Spain represents 10%, a relatively high level compared to other high-income European countries (Ángel Martinez Jorge et al., 2022).

In Spain children and adolescents consume 22% of dietary energy in the form of total sugars. One third of the calories in the Spanish household shopping basket and two thirds of the total sugar consumed comes from ultra-processed foods and sugar-sweetened beverages. The consumption of sugar-sweetened beverages (SSBs) is common in the Spanish population and is one of the main factors contributing to overweight and obesity. 40% of the child and adolescent population in Spain are regular consumers of SSBs. Low-income Spanish households consume more SSBs (Gobierno de España - Ministerio de Sanidad, 2022; Royo-Bordonada et al., 2022). In the obesity debate, policies on sugar consumption have been gaining weight and have come to occupy an important place (Ángel Martinez Jorge et al., 2022).

The Spanish Agency for Food Safety and Nutrition (AESAN) launched in 2005 the Strategy for Nutrition, Physical Activity and Obesity Prevention (NAOS). The purpose of this strategy is to reverse the trend in the prevalence of obesity through the promotion of a healthy diet and physical exercise. The NAOS Strategy was reinforced in 2011 by Law 17/2011 on food security and nutrition (Nutri-Score Scientific Committee, 2021).

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3.1.2. Sugar-sweetened beverage policies in Spain

In 2017 the government of Catalonia (Spain) created a tax on Sugar-sweetened beverage (SSBs) (Fichera et al., 2021). This tax was created in compliance with the recommendation of the World Health Organisation (report of 11 October 2016), which promotes tax measures on sugary drinks with the aim of reducing problems such as obesity and certain types of diabetes. The main objective is to tax the consumption of SSBs because of their effects on the health of the population (Gobierno de Cataluña, 2017).

In January 2021 the Spanish government increased the value added tax (VAT) on sugary and sweetened beverages from 10% to 21%. It is one of the most significant policies of the last 10 years in the fight against the negative effects sugar has on general health and childhood obesity (Ángel Martinez Jorge et al., 2022).

This tax also applies to "zero/light" products containing sweeteners. On the other hand, SSBs consumed in restaurants are excluded from this increase. This exception is intended to avoid affecting the post-pandemic recovery of the sector (Ángel Martinez Jorge et al., 2022; Martínez & Martínez, 2022). In Spain there are three regions, the Canary Islands, Ceuta and Melilla, which have their own indirect taxes and are not affected by the VAT increase in 2021 (Ángel Martinez Jorge et al., 2022).

3.1.2.1. Description of policy instruments

3.1.2.1.1. Tax on sugar-sweetened beverages in Catalonia

Law 5/2017 of 28 March 2017 establishes that the taxable event is the acquisition of sweetened beverages, whether free of charge or against payment, by the taxpayer, due to the effects that the consumption of these beverages has on the population. The taxable amount is the quantity in litres of packaged sugar-sweetened beverages delivered by the distributor and purchased by the taxpayer. The rate of the tax is:

4. Eur 0.08 per litre for drinks with a sugar content between 5 and 8 grams per 100 millilitres.
5. Eur 0.12 per litre for drinks with a sugar content of more than 8 grams per 100 millilitres.

The tax becomes chargeable at the time of purchase of the SSBs in the territory where the tax is levied, by the taxpayer from the distributor.

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3.1.2.2. Mechanisms of the instrument for internalization

3.1.2.2.1. Pass-through to prices

Studies that analysed the effects of the VAT increase on the consumption of SSBs in Spain shows that more than 90% of the VAT increase ended up being passed on to the final price. This corresponded to an approximate average increase in the amount per litre of 12 cents (+9.6% on the average price per litre) (Figure 6). The effect of the tax on soft drink prices was large and statistically significant (Ángel Martinez Jorge et al., 2022; Martínez & Martínez, 2022).

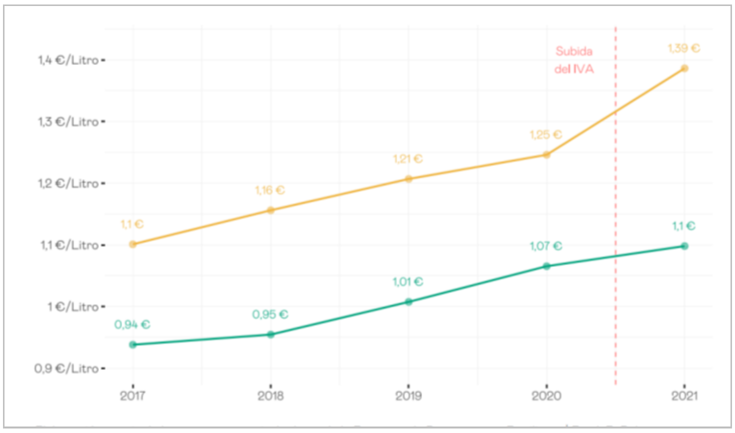

Figure 6. Evolution of the price of SSBs in Spain
Green: Households in regions with no increase for SSBs
Orange: Households with VAT increase for SSBs.

The prices of sugar-sweetened beverages show that the tax was passed on to Catalan consumers (8.3% for small packs and 17.5% for large packs) (Royo-Bordonada et al., 2019). Royo-Bordonada et al. (2022) compared the prices of sugar-sweetened beverages in Catalonia and the rest of Spain before and after the imposition of the tax and showed that the price of sugar-sweetened beverages increased from 0.95 in 2013/2014 to 1.17 €/l in 2019/2020 in Catalonia, and from 0.83 to 0.95 €/l in the rest of Spain. This represents an increase of 23.2% in the price in Catalonia and 14.5% in the rest of Spain (table 1 - Adjusted for price data only).

Table 1. Price of beverages in Catalonia and Spain 2013–2020 (Royo-Bordonada et al., 2022)

Variable	Geographical area	Pre-tax period				Post-tax period		
		2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
Price (€/L)								
Sugar-sweetened beverages	Catalonia	0.95	0.99	1.03	1.07	1.09	1.11	1.17
	Rest of Spain	0.83	0.84	0.87	0.89	0.89	0.92	0.95
Sugar-free beverages	Catalonia	0.86	0.90	0.91	0.96	0.94	0.94	0.99
	Rest of Spain	0.78	0.77	0.80	0.83	0.84	0.87	0.90

3.1.2.2.2. Public awareness

A study interviewing more than 1,000 Spanish respondents shows that 92% of respondents believe that excessive consumption of sugary drinks causes obesity, and two out of three people are in favour of a tax on sugary drinks (Fernández Sánchez-Escalonilla et al., 2022).

The sugar-sweetened beverage tax in Catalonia was justified on health reasons and was implemented after a long public debate in the media. This had a positive influence on increasing public awareness of both the tax and the health risks of sugary drinks. The results of Royo-Bordonada et al. (2019) show that the main reason for Spanish consumers to reduce their consumption of sugar-sweetened beverages was the price increase, followed by increased awareness of their health effects (table 2).

Table 2. Knowledge of the tax on (SSBs), changes in consumption, and reasons for the change reported by the 455 participants in the post-tax sample (2018) in low income neighbourhoods of Barcelona.

	N (%)
Knows of the existence of the tax	407 (83.4%)
Reports change in consumption[a]	152 (37.3%)
Direction of change in consumption [b]	
Reduction in consumption	117 (77.0%)
Replacement by untaxed beverages	9 (5.9%)
Replacement by own-brand beverages	12 (7.9%)
A combination of the above	14 (9.2%)
Reason for change in consumption [b]	
Increase in price	102 (67.1%)
Health awareness	34 (22.4%)
Increase in price and health awareness	12 (7.9%)
Others	4 (2.6%)

[a] Percentage calculated with respect to the 407 participants who knew of the existence of the tax
[b] Percentage of the 152 participants who reported having changed their consumption of beverages as a result of the tax's introduction

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The Food and Agriculture Organisation of the United Nations (FAO) carried out a study to analyse the effects of the tax on sugar sweetened beverages in Catalonia. The results show that the main reason for Spanish consumers to reduce their total or partial consumption of sugar sweetened beverages is awareness of the health risks (98.5% of respondents) (figure 7). However, this trend regarding awareness of health risks is lower in young people (table 3). This study concludes that awareness of the existence of such a tax contributes to an increased awareness of the health risks of sugar sweetened beverages (Food and Agriculture Organization of the United Nations, 2021).

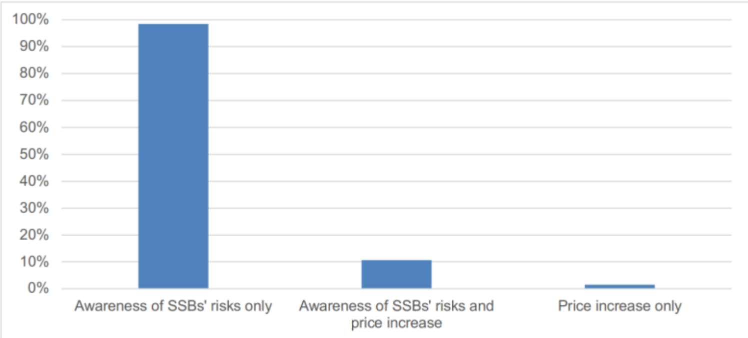

Figure 7. Respondent's declared motives for reducing consumption of SSBs

Table 3. Significant associations between explanatory variables and socio-demographic characteristics

Explanatory variables	Socio-demographic characteristics	Relevant percentages
Recent knowledge of SSBs' health risks	Age	<18–24: 56.5% 25–44: 82.8% 45–54: 82.9% 55–64: 78.6% ≥65: 64.1%
Awareness of the tax	Age	<18–24: 32.6% 25–44: 53.1% ≥65: 66.7%
Awareness of the tax	Gross annual income	Low: 49.6% High: 75%
Awareness of the tax	Current consumption of SSBs	Low: 67.7% High: 43.1%
Awareness of the price increase	Age	<18–24: 37% 25–44: 46.9% ≥65: 7.7%
Awareness of the price increase	Gross annual income	Low: 45.5% High: 19.4%
Awareness of the price increase	Current consumption of SSBs	Low: 16.1% High: 58.3%
Awareness of the price increase	Neighbourhood	Les Roquetes: 48.3% Sarria: 25%

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3.1.2.2.3. Product reformulation

Several studies show that the volume-based tiered tax has an impact on the reformulation and reduction of the sugar content of sugar sweetened beverages (Andreyeva et al., 2022).

3.1.2.3. Policy impacts

There is scientific evidence that in the case of taxes on sugar sweetened beverages consumers respond to economic interventions (Andreyeva et al., 2022). The tax on sugar sweetened beverages in Catalonia has helped to raise awareness among Spaniards about the health risks of sugar sweetened beverages. However, it is key that strategies to disseminate and socialise this measure among the population, especially among the youngest and poorest, are improved. Communication campaigns on this tax should be clear, easy to understand and widely disseminated, in order to increase its positive impact in the long term (Food and Agriculture Organization of the United Nations, 2021).

3.1.2.3.1. Impact on consumption

Historically, taxes have been used to correct negative externalities in consumption. In recent years, sugar taxes have established themselves as the ideal measure to discourage the consumption of SSBs (Ángel Martinez Jorge et al., 2022; Martínez & Martínez, 2022). Some studies show that the effect of price increases on the quantity of soft drinks consumed was significant in lower income households. For 33% of these households the average decrease was 11/12 litres per year (especially among households with children between 5 and 16 years old). This equates to a fall in consumption of 13%. However, in upper middle-income households the measure had no appreciable effect.

One of the Spanish government's objectives with this policy is to discourage sugar consumption in order to reduce childhood obesity. That is why the results of these studies are relevant considering that in low-income households with children between 5 and 16 years of age, the reduction in consumption reached 25 litres per household per year (Ángel Martinez Jorge et al., 2022; Martínez & Martínez, 2022).

Another study interviewing young people in Barcelona and Madrid (Spain) shows that one year after the entry into force of the Catalan tax on sugary drinks, there was a significant decrease (39%) in the prevalence of regular consumers of sugar-sweetened beverages (Royo-Bordonada et al., 2019).

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The study of Royo-Bordonada et al. (2022) also showed a 40.3% reduction in sugar-sweetened beverage consumption in Catalonia and 27.8% in the rest of Spain in the period 2013 – 2020. Table 4 (Modified for consumption only) shows a more significant reduction in consumption two years after the imposition of the sugar-sweetened beverage tax in Catalonia.

Table 4. Consumption of beverages in Catalonia and Spain 2013–2020 (Royo-Bordonada et al., 2022).

Variable	Geographical area	Pre-tax period				Post-tax period		
		2013/14	2014 /15	2015 /16	2016 /17	2017 /18	2018 /19	2019 /20
Per capita consumption (L/month)								
Sugar-sweetened beverages	Catalonia	1.86	1.73	1.53	1.31	1.24	1.13	1.11
	Rest of Spain	1.51	1.45	1.36	1.30	1.20	1.09	1.09
Sugar-free beverages	Catalonia	0.99	0.86	0.87	0.76	0.92	1.04	1.13
	Rest of Spain	1.06	1.04	1.07	1.03	1.04	1.06	1.13

3.1.2.3.2. Impact on consumption purchases/patterns

Per capita purchases of sugar-sweetened beverages decreased by 0.17% three and a half years after the implementation of the excise tax on sugar-sweetened beverages in Catalonia (Figure 8 - adapted for per capita consumption only). This represents a relative decrease of 16.71% (Royo-Bordonada et al., 2022).

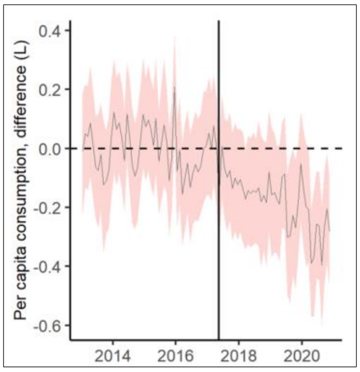

Figure 8. Monthly difference between observed per capita consumption of selected sugary drinks in Catalonia, Spain (Royo-Bordonada et al., 2022).

Royo-Bordonada et al., (2019) pointed out that 37.4% of consumers in Barcelona (Spain) reported a change in their non-alcoholic beverage consumption habits as a result of the sugar-sweetened beverage tax. In addition to a reduction in consumption there was evidence of a partial or total substitution of taxed beverages by other non-taxed or own-brand beverages. Two years after the entry into force of the tax on sugar sweetened beverages in Catalonia, it became clear that this measure had a negative impact on purchases of regular cola (12.1% decrease). This in turn led to a 17% increase in purchases of diet cola (figure 9) (Puig-Codina et al., 2021).

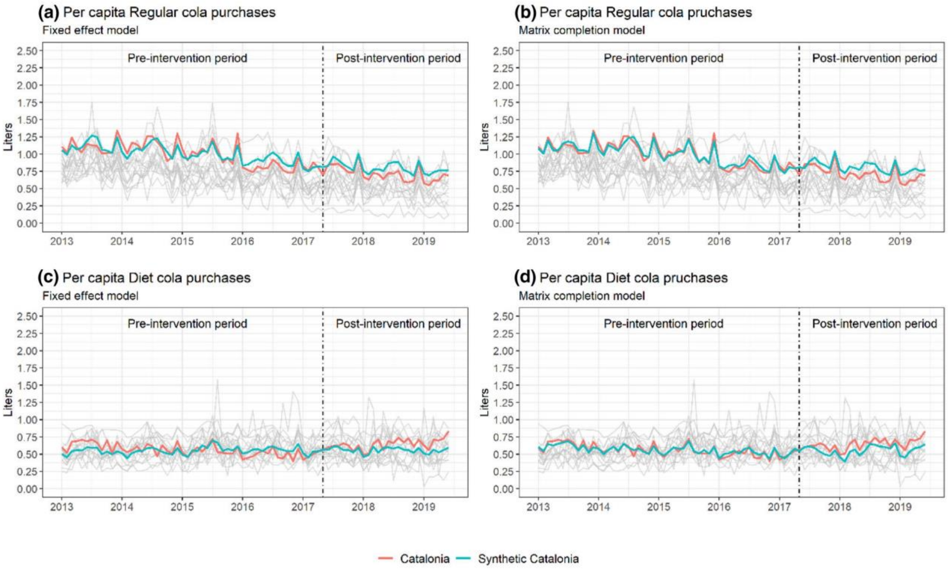

Figure 9. Monthly Trends in regular and diet colas purchases (Catalonia vs. synthetic Catalonia) (Puig-Codina et al., 2021)

3.1.2.3.3. Impacts on externalities

3.1.2.3.3.1. Impacts on economic externalities

3.1.2.3.3.1.1. Spillovers

Results from the application of an econometric model ("lead and lags") show that the effect of the VAT increase on SSBs appears to have a spillover effect on snack spending. Consumption of snacks among lower income households fell by €5 per household per year, a drop of 11%. This shows that the policy had additional effect on other commonly consumed products that are also considered potentially harmful to health (Ángel Martinez Jorge et al., 2022; Martínez & Martínez, 2022).

4. Climate change mitigation

4.1. GHG emissions

4.1.1. Introduction

Currently, one of the main threats to sustainable development is climate change. This phenomenon, which is producing negative impacts in many regions of the planet (heat waves, droughts, floods…), represents a major environmental challenge due to its effects on the global economy, health and social welfare (World Meteorological Organization, 2021). Spain, due to its geographical location and socio-economic characteristics, is a country especially vulnerable to the effects of climate change. Key sectors such as agriculture, forestry, tourism and transport are beginning to be affected by the effects of this phenomenon (Ministry for the Ecological Transition, 2020).

The Spanish State Meteorological Agency has clear evidence of the impacts that climate change has had on Spain over the last 40 years. According to the agency's figures, there are currently more than 32 million people directly affected by its consequences. The new scenario of climate change in Spain makes evident the expansion of semi-arid climates, the lengthening of summers, more days of heat waves and tropical nights and the increase in the surface temperature of the Mediterranean (Ministry for the Ecological Transition, 2020).

In Spain, agriculture, livestock, fisheries and aquaculture are strategic sectors, with great economic, social, territorial and environmental importance. In addition, the food industry is the leading industrial sector. The impacts of climate change on the Spanish agricultural sector include crop damage and losses and disturbances due to increased extreme weather events; reduced crop yields; changes in pest and disease patterns; displacement of areas suitable for certain crops; and increased photosynthetic rates of some crops due to increased atmospheric concentration (Ministry for the Ecological Transition, 2020). Recent studies show that climate change will negatively affect agricultural areas in northern Spain and the Mediterranean region. This is mainly because water resources will come under pressure and nitrate pollution of surface and groundwater will increase (Jebari et al., 2023; Oduor et al., 2023).

In the livestock sector, the effects of climate change are reflected in livestock heat stress, reduced livestock production due to disease, reduced pasture availability, changes in pest and disease patterns and dietary imbalances. In fisheries, there is evidence of geographical redistribution of marine species due to warming, acidification and loss of oxygen from seawater. Variations in catch yields are also a consequence of climate change (Ministry for the Ecological Transition, 2020).

On the other hand, although these sectors suffer the consequences of climate change impacts, they are themselves largely responsible for the emissions that cause climate change. In Spain, the estimated gross greenhouse gas (GHG) emissions for 2020 were 274,743 kilotonnes of CO2-eq, which represents a reduction of 7.8% compared to 1990. Almost three quarters of global emissions (72.5%) originated in the energy processing sector.

Emissions from agricultural activities accounted for 14% of overall emissions and emissions from industrial processes accounted for 8.6%. Emissions from waste management activities ranked fourth with 4.8% of total emissions (Ministerio para la Transición Ecológica y el Reto Demográfico, 2022). In northern Spain, between 27%-49% of Greenhouse Gas Emissions (GHG) correspond to CH_4 produced by dairy farms. Another significant percentage of these total emissions comes from manure management (enteric fermentation) (Jebari et al., 2023).

In response to the need to implement strategies to safeguard the environment, health and safety of citizens, the Spanish government has developed a set of legal instruments aimed at addressing the climate emergency. This set of rules, strategies and plans addresses the causes of the phenomenon, setting out a roadmap for achieving climate neutrality by 2050, and also the consequences, with a new Climate Change Adaptation Plan for the period 2021-2030 (Ministerio para la Transición Ecológica y el Reto Demográfico, 2021).

The Spanish government approved the National Energy Efficiency Action Plan 2017-2020. This plan includes obligations on energy efficiency and other action measures and/or a framework of support or incentives for market agents to carry out other energy efficiency improvement measures (Ministerio para la Transición Ecológica y el Reto Demográfico, 2022).

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4.1.2. Description of policy instruments

4.1.2.1. Production Standards (obligations)

Royal Decree 637/2021 on the basic rules for the management of poultry farms establishes mandatory measures for new farms of hens, chickens and turkeys. These measures include those related to the reduction of polluting gases. For example, the reduction of total nitrogen excreted and ammonia emissions.

4.1.2.2. Communications and registers

Royal Decree 637/2021 establishes that farmers must communicate/report annually to the public authority the Best Available Techniques (BAT) used for the reduction of pollutant and greenhouse gas emissions during the previous year.

4.1.2.3. Subsidies

4.1.2.3.1. Subsidies for the renewal of the national fleet of agricultural machinery.

This subsidy, regulated by Royal Decree 1055/2021, is aimed at providing incentives for the acquisition of different types of machinery with the aim of reducing CO_2, NOx, N_2O, NH_3 and particle emissions, optimising the application of inputs and fixing carbon in the soil by carrying out conservation agriculture or no-tillage practices. Among the machinery and/or equipment subsidised are agricultural tractors, shredders of harvest and pruning residues, self-propelled handling and loading machines or electric tractors, equipment for the application of phytosanitary products and fertilisers, direct seeders, etc. This aid is part of the measures defined by the Spanish government in the *Plan for the Renewal of the National Fleet of Agricultural Machinery*.

4.1.2.3.2. Subsidies for the renewal of agricultural tractors

This subsidy, which is regulated by Royal Decree 147/2014, promotes the scrapping of tractors older than fifteen years and their replacement by new tractors. The main objective is to encourage, together with the commercial effort of manufacturers, importers and marketers, the acquisition of these vehicles, fulfilling the objective of reducing CO_2 emissions, and at the same time, particulate emissions, which are precisely the pollutants that most directly affect health.

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The average reduction per tractor replaced will be 94% of particles, as well as 15-20% of CO_2 emissions per tractor. This aid is part of the measures defined by the Spanish government in the "*Plan de Impulso al Medio Ambiente - PIMA Tierra*", which promotes the scrapping of old tractors and their replacement by new ones with greater energy efficiency and lower pollutant emissions.

4.1.2.3.3. Subsidies for support programmes for investments to boost the sustainability and competitiveness of agriculture and livestock farming

This aid, regulated by Royal Decree 948/2021, is part of the Spanish government's Recovery, Transformation and Resilience Plan. Their main objective is to support programmes for investments to boost the sustainability and competitiveness of agriculture and livestock farming through improvements in manure management systems on livestock farms, the modernisation and integral transformation of greenhouses for vegetables, cut flowers and ornamental plants, the implementation of energy efficiency measures on farms and the use of energy from livestock by-products and agricultural biomass.

Among the actions supported is the improvement of the environmental efficiency of livestock manure outdoor storage facilities. This consists of carrying out one or more investments related to the adaptation or covering of new or existing external manure ponds/deposits, with or without energy use on the farm itself, which reduce emissions of ammonia, greenhouse gases and polluting gases.

4.1.3. Mechanisms of the instrument for internalization

4.1.3.3. Increased production costs and final price of products

A study that analysed the Best Available Techniques applied in poultry production in different European countries, including Spain, shows that the adoption of some of these techniques generates additional costs for farmers. This is mainly because in some cases they require materials, equipment, expert personnel, inputs, special techniques, among other aspects that increase investment costs (Giner Santonja et al., 2017).

4.1.4. Policy impacts

A study analysed the barriers and opportunities for the adoption of soil carbon management practices in European sustainable agricultural production. This study, which included among others Spain as a case/region of analysis, concluded that one of the

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strategies to encourage the implementation of soil carbon management practices is to provide incentives to promote their adoption.

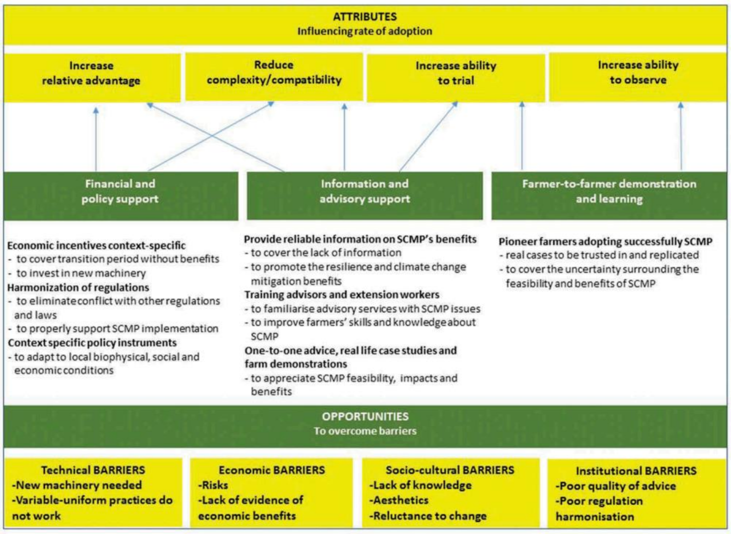

Figure 10. Opportunities to promote the adoption of soil carbon management practices (Mills et al., 2020)

Capital subsidies for the purchase of machinery could help to overcome one of the main economic/technological barriers (Mills et al., 2020) (figure 10). According to the results of previous studies, subsidies for the purchase of machinery in China have a positive impact on agricultural production. However, there is a recognised need for improvement in some aspects related to coverage, product quality and after-sales services. According to Chinese farmers who were interviewed, the main barrier to the use of machinery is the high cost of purchase and maintenance. Therefore, it is considered that agricultural machinery subsidies can be an alternative to eliminate this barrier (Huo et al., 2022).

A study focused on analysing the effects of government subsidies for the purchase of agricultural machinery in China. The main results show that the subsidy for the purchase of agricultural machinery had a clear incentive effect. It highlights that this subsidy effectively promotes farmers' self-investment in agricultural machinery. It also points out that in the analysis cases the effect of the subsidy increased with the increase in the value of agricultural machinery, and the effect of the policy was higher for large and medium-sized agricultural machinery (Leng et al., 2020).

4.1.4.1. Impacts on externalities

4.1.4.1.1. Impacts on environmental externalities

4.1.4.1.1.1. Reduction of methane emissions

A study evaluating different techniques (BAT) that were implemented on Spanish poultry farms to reduce ammonia emissions from poultry farms confirmed that these techniques are effective in reducing methane emissions (Giner Santonja et al., 2017). In 2022 the Spanish government in the framework of the United Nations Convention on Climate Change and the Kyoto Protocol presented the report with the progress made by Spain in fulfilling its commitments on climate change and the actions taken and planned for the short, medium and long term (Ministerio para la Transición Ecológica y el Reto Demográfico, 2022).

4.1.4.1.1.2. Reduction of energy consumption

This report presents a summary of the cumulative (annual and additional) final energy savings between 2014 and 2020 achieved for each of the measures of the obligation scheme and the alternative measures (Table 5). One of the measures evaluated is the "PIMA Tierra (tractors)" programme. According to the figures presented, energy savings are evidenced by the replacement of agricultural tractors through the government subsidy programme (Ministerio para la Transición Ecológica y el Reto Demográfico, 2022).

Table 5. Summary of (annual and additional) final energy savings 2014-2020

Medida política	Ahorro acumulativo [ktep] expresado en energía final						
	2014	2014-2015	2014-2016	2014-2017	2014-2018	2014-2019	2014-2020
PIMA Tierra (tractores)	0,70	1,40	2,10	2,80	3,50	4,20	4,90

4.1.4.1.1.3. Reduction of fertiliser use

Studies in rice cultivation in China show that subsidies that encourage the purchase of farm machinery help to reduce fertiliser use and improve resource use efficiency (Figure 11). Farm machinery helps to loosen the soil for easier and more rational application of fertiliser products (Guo et al., 2021; He et al., 2022).

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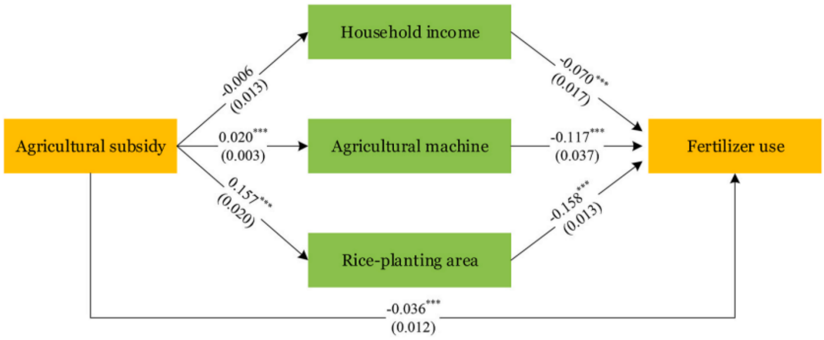

Figure 11. Results of mediating effect (Guo et al., 2021).

4.2. Renewable energy

The Spanish government elaborated the National Integrated Energy and Climate Plan 2021-2030 (PNIEC). This plan identifies the challenges for the five dimensions of Energy: decarbonisation, including renewables; energy efficiency; energy security; the internal energy market; and research, innovation and competitiveness. security; the internal energy market; and research, innovation and competitiveness (Ministerio para la Transición Ecológica y el Reto Demográfico, 2020).

This plan expects a significant growth of renewable energies in Spain, reaching 74% of electricity and 42% of final energy use by 2030. The main objective is to increase the use of renewable energy as a proportion of final energy consumption and to take advantage of the social and economic opportunity of this deployment through different strategies included in the plan (Spanish Government, 2021).

On the other hand, the Spanish government's Recovery, Transformation and Resilience Plan includes among its main objectives a just and inclusive energy transition and as a strategy the deployment and integration of renewable energies (Spanish Government, 2021).

4.2.1. Description of policy instruments

4.2.1.1. Subsidies

4.2.1.1.1. Subsidies for the implementation of renewable energy installations and improvement of energy efficiency

Royal Decree 1124/2021 regulates subsidies for the implementation of thermal renewable energy installations in the industrial, agricultural, service and other sectors of the economy. The purpose of this royal decree is to comply with the objectives of the Recovery, Transformation and Resilience Plan regarding the deployment and integration of thermal renewable energies, thereby contributing to the decarbonisation of different sectors of the economy, as well as to the achievement of the objectives set by the PNIEC 2021-2030.

The Government of Navarra (Spain) through Resolution 2E/2022 regulated aid for the storage and use of renewable energies to optimise their use in companies located in the region of Navarra.

Royal Decree 197/2016 regulates subsidies for financial support to cooperation for joint approaches to environmental projects and ongoing environmental practices aimed at improving energy efficiency through the use of renewable energies. This decree prioritises the use of renewable energies in the agri-food sector by the priority associative entities and/or agri-food SMEs participating in the cooperation. This subsidy programme is part of the National Rural Development Programme 2014-2020.

Royal Decree 1010/2015 regulates aid for tangible or intangible investments in processing, marketing and development of agricultural products. Eligible actions include the incorporation of alternative energies in the agri-food industry: renewables and new fuels, the incorporation of cogeneration, the improvement of energy efficiency and the reduction of emissions into the natural environment.

5. Natural resource & ecosystem management

5.1. Fishery & aquaculture

The marine environment is subject to significant threats from human activity. In areas along the Mediterranean coast, many Posidonia meadows have disappeared due to trawling. This type of fishing, carried out on a continuous and intensive manner, has also led to the destruction and alteration of the habitats of the sedimentary bottoms of the continental shelf. Overexploitation of marine resources due to industrial fishing, eutrophication and pollution from the use of chemicals, fossil fuels and wastewater are other major problems currently facing marine ecosystems (Fernando Valladares Ros et al., 2017).

In Spain, fishing and aquaculture is a very important economic activity in certain coastal areas. In terms of the importance of the different regions, all the autonomous communities with a coastline have interests in the fisheries sector, however, Galicia, Andalusia, País Vasco and the Islas Canarias stand out. In order to face the different challenges of this sector and to guarantee the sustainability of fishery resources from a biological, economic and social point of view, the Spanish government has prioritised different plans, strategies and policies (Ministerio de Agricultura, 2015; Ministerio de Medio Ambiente y Medio Rural y Marino, 2007).

5.1.1. Description of policy instruments

5.1.1.1. Production Standards (obligations)

Law 3/2001, of 26 March, regulates maritime fishing, establishing compulsory measures for the conservation, protection and regeneration of fishing resources. This law establishes the basic regulations for the organisation of the fishing sector and the bases for the marketing and processing of fishery products. Royal Decree 1044/2022 establishes all the requirements/procedures to be followed by fishing fleet owners.

5.1.1.2. Labelling and validation of capture documents

The Resolution of 28 April 2023 lays down the detailed rules for the implementation of the multi-annual management plan for bluefin tuna in the Eastern Atlantic Ocean and Mediterranean Sea for 2023. This resolution stipulates that all tuna caught by directed fishery or by-catch on Spanish vessels must be subject to a system of individual labelling.

This resolution also includes specific instructions for the use, completion and validation of the electronic catch document and paper catch document for bluefin tuna.

5.1.1.3. Subsidies for investment projects in the fisheries and aquaculture sector

Royal Decree 685/2021, of 3 August, regulates subsidies for groups of entities that carry out investment and reform projects in research for technological development, innovation and the balance of the commercialisation chain in the fishing and aquaculture sector within the framework of the Recovery, Transformation and Resilience Plan.

These subsidies are part of Component 3 (Environmental and digital transformation of the agri-food and fisheries system) of the Plan for the Recovery, Transformation and Resilience of the Spanish Economy, corresponding to Investment 8 (Plan to promote sustainability, research, innovation and digitalisation of the fisheries sector (III): Technological development and innovation in the fisheries and aquaculture sector), in the second of its elements: support for technological development and innovation in the sector. Thematic areas, Priority actions and eligible lines include:

Priority Action 1. Living marine resources - Impact of climate change: Studies of population changes due to climate change (new species in fishing grounds, migration of current species, changes in abundance, etc.).

Priority Action 2: Fisheries management and planning - Fisheries management systems: ecosystem approach, marine ecosystem valorisation studies, regional or basin coordination, interrelation between the different actors (managers, scientists, fisheries sector, etc.), improvement of the electronic logbook on board, etc.

Priority Action 3: Animal health. - Parasitism. Study of parasites, mitigation measures, Anisakis extermination systems, management of viscera with parasitosis - Toxics, heavy metals: studies of concentration in the environment and accumulation in marine organisms, establishment of permitted limits.

Priority Action 4: Sustainability and environmental impact - Marine litter: collection, management on board and ashore, prevention and awareness raising - Impact of marine reserves on biodiversity - Monitoring and study of non-native and invasive species.

Royal Decree 1155/2021, of 28 December, establishing the regulatory bases for subsidies to groups of entities that carry out blue growth projects in the fisheries and aquaculture sector, and calling for applications for 2022 and 2023. Eligible blue growth projects include those related to:

- Fight against marine pollution: collection and recovery of waste -especially plastics-, giving them industrial use, promoting, intersectoral alliances and between different actors, to approach a circular economy.
- Adaptation to climate change: integrated assessment of marine ecosystems and the impacts associated with fishing and shellfishing, artisanal and recreational activities.
- Decarbonisation of the fisheries sector: substitution of fossil fuels for clean energy in the fishing and aquaculture sector, processing and marketing.

Royal Decree 854/2021 regulates subsidies for the acquisition and installation of remote electronic monitoring (REM) systems, for compliance with the landing obligation, for the digitisation of the small-scale fleet and for support to the extractive, aquaculture and marketing fishing sector. This decree is part of one of the components of the Spanish Recovery, Transformation and Resilience Plan, specifically in the measure to boost sustainability, research, innovation and digitalisation of the fishing sector (IV): Digitalisation of the means for monitoring the fishing fleet. This measure aims to improve the monitoring of fishing activity in order to guarantee environmental sustainability and the medium and long-term viability of the fishing sector.

5.1.2. Policy impacts

Some authors suggest that governments need to strike the right balance in designing regulatory instruments to reap the benefits of aquaculture while preserving the environment. A thorough assessment is needed to determine the marginal benefit of aquaculture production and its associated marginal social costs (Abate et al., 2016).

5.1.2.1. Impact on production and growth of the sector

A study analysing subsidies to aquaculture in European Union countries points out that most EU countries base their regulations on command-and-control instruments to manage negative environmental externalities. However, it stresses that such regulations are inflexible, do not encourage producers to adapt and develop new technologies and do not guarantee greater efficiency in production. In the case of the aquaculture sector, the application of very strict environmental regulations has been partly a cause of reduced growth in the EU aquaculture sector (Guillen et al., 2019).

This theory is supported by previous research that conducted a cross-country regression analysis to identify the relationship between the stringency of environmental regulations and aquaculture growth. The empirical results reinforce the theory that strict environmental regulations hinder aquaculture growth. Regulatory instruments are often outdated and ineffective, which has a negative impact on the long-term sustainable growth rate of aquaculture in developed countries compared to rates in emerging and/or developing countries (Abate et al., 2016).

Guillen et al. (2019) propose the application of incentive-based regulation, such as individual transferable quotas or environmental impact taxes, to induce economically optimal management and further growth of the aquaculture sector in the EU.

5.1.2.2. Impacts on externalities

5.1.2.2.1. Impacts on environmental externalities

Sumaila et al.,(2010) note that subsidies that promote conservation and management of fisheries resources are considered necessary and beneficial. This author also points out that the level of subsidies granted by governments around the world to the fisheries sector is high and that this could lead to overcapacity and overfishing. It therefore suggests eliminating harmful subsidies and redirecting subsidies to programmes or schemes for improved fisheries management and recovery of stocks affected by overfishing (Sumaila et al., 2010, 2019).

6. Waste management

6.1. Waste

The Spanish government adopted the Waste and Contaminated Land Law of 2021 as a transposition of the EU waste directive. Several Autonomous Communities developed their own regulatory frameworks on food waste before national legislation was in place (Quintanero et al., 2022). Spain is one of the European countries with the highest production of food waste (Penalver et al., 2022). The "More food, less waste" strategy is one of the most relevant actions at the national level and has managed to involve different sectors of society (Quintanero et al., 2022). Spanish companies in the food industry are increasingly aware of the economic, social and environmental impact of food waste and the need to reduce it.

In recent years, the evolution of the Spanish pig sector has led to an important process of intensification in production systems and an increase in the by-products generated on pig farms. Manure resulting from livestock activity represent a potential danger for the environment, with problems linked to the emission of gases into the atmosphere, water pollution and excess assimilable nitrogen in agricultural land.

Royal Decree 1528/2012 lays down the specific provisions for the application in Spain of Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules concerning animal by-products and derived products not intended for human consumption.

The Spanish government seeks to encourage the development of joint management systems that offer innovative solutions to the current problems of slurry disposal from animal farms, facilitating its recovery for different uses. The development of policies at national level on this issue and the promotion of agricultural practices compatible with the natural environment reflect a growing social concern for the conservation and sustainability of the environment.

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6.1.1. Description of policy instruments

6.1.1.1. Legal prescription and specification

Navarre Government Law 7/2013 establishes that retailers must implement a waste management plan aimed at waste minimisation and correct treatment. In the event of generating food waste, they must consider a plan for its use through agreements with the Food Bank of Navarre or other similar entities.

6.1.1.2. Subsidies

6.1.1.2.1. Subsidies for the improvement of the technical capacity for the management of animal by-products

Royal Decree 1178/2008 regulates aid to promote investment in structures related to the management of animal by-products not intended for human consumption, with the aim of improving the structural capacity and economic sustainability of the general system for the management of such by-products. The aid is targeted at livestock holdings, agri-food industries and by-product management establishments. This decree includes four specific lines of aid to cover each link in the chain of production, storage, processing and recovery of animal by-products.

6.1.1.2.2. Subsidies for projects to improve the environmental management of pig farms

Royal Decree 987/2008 regulates subsidies to promote the development of innovative systems for the management of slurry from pig farms, respectful and compatible with the protection of the environment, that avoid inefficient energy consumption, that contemplate an integral approach to recovery and development of technical improvements available in the application of slurry to the field, through:

- The implementation of recovery and management programmes that involve the reduction of the use of mineral fertilisers, through the application of new techniques that allow the appropriate incorporation of slurry into the soil, reducing pollution.

- The development of other innovative alternatives in the management of slurry from pig farms, including pilot projects or demonstration projects on a reasonably small scale.

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6.1.1.2.3. Subsidies to cooperation for sustainable biomass supply

This aid, regulated by Royal Decree 254/2016, is part of the National Rural Development Programme. The main objective is to provide financial support to cooperation projects for the sustainable supply of biomass between agents that receive or supply it, for the production of energy in the transformation of agri-food products. This supply of biomass is done in parallel and in a complementary way to the value chain of the companies in the sector involved in the production, processing and distribution of food or food products, which entails a benefit to the priority associative entities or supra-autonomous agri-food SMEs involved.

6.1.2. Mechanisms of the instrument for internalization

6.1.2.1. Increased production costs and final price of products

Esturo et al., (2010) evaluated the implications of the implementation of the measures of Regulation (EC) No. 1774/2002 (Repealed by Regulation (EC) No. 1069/2009) adopted in Spain through Royal Decree 1528/2012 on the regulation of animal by-products that are not intended for human consumption. This study analyzed in detail the generation and management of animal by-products in the different stages of the meat production chain. Likewise, the transmission of the costs associated with the implementation of the regulation throughout the production chain. The results show an unequal distribution of regulatory costs. Farmers must assume double the costs by having to invest in infrastructure and equipment for the treatment of by-products.

In the same way, Esturo et al., (2010) points out that the transmission of costs to final consumers depends on the type of animal. In the case of cattle and sheep, the lack of competitiveness in their markets also interferes with the transmission of prices and the cost of applying the regulation. In relation to subsidies, a large part of the investments made by farmers are subsidized by the government. By-product processing plants have also received higher subsidies than in other sectors (Esturo et al., 2010).

6.1.3. Policy impacts

Aramyan et al., (2016) Identified a number of market-based instruments (MBIs) and incentives that can be applied to the design of food waste reduction and prevention policies. These authors highlight that most of the instruments identified in the analysis are price-based, which can be both positive and negative incentives. Negative incentives are, for example, the taxation of wasted food. Positive incentives, on the other hand, seek to motivate actors to certain actions in exchange for a reward. Examples are subsidies for food waste reduction technologies or tax incentives for the donation of food waste (Aramyan et al., 2016).

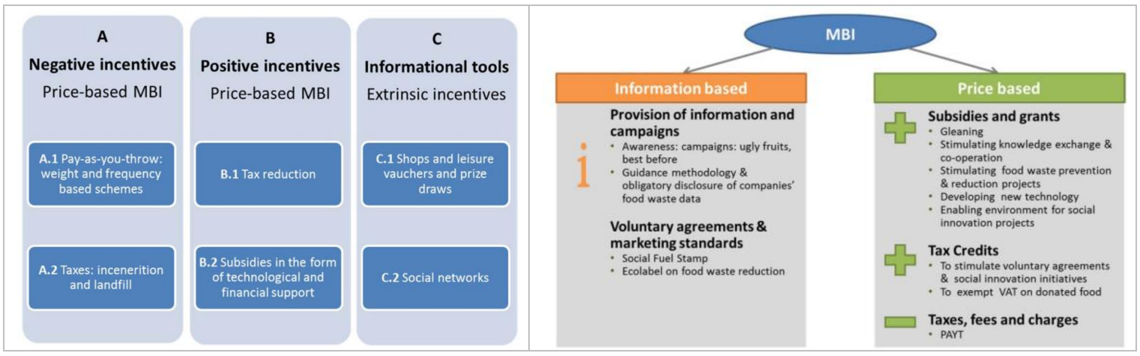

Figure 12 and 13. MBIs and economic incentives toolbox to prevent and reduce food waste (Aramyan et al., 2016)

These positive price-based instruments are voluntary. Although they entail costs for governments and other actors in the chain, the benefits from waste reduction outweigh the costs. The implementation of such instruments is simple, involves few risks and represents economic and social benefits due to waste reduction and job creation (Aramyan et al., 2016). Figures 12 and 13 summarise the most promising MBIs for food waste reduction and prevention (Aramyan et al., 2016).

Quintanero et al., (2022) made an assessment of the current legal framework against food waste in Spain and the Foral Law 7/2013 scores well in both the civil society and the private sector. A correct mention and articulation of both sectors was found throughout the legislative text.

6.1.3.1. Impacts on externalities

6.1.3.1. Impacts on environmental externalities

A study analysed the carbon footprint of the Food Bank of Navarra (FBN). It compared greenhouse gas emissions in two scenarios, "with" and "without" FBN's actions in order to identify and quantify the reduction of GHG emissions associated with the reduction of food waste. This study showed that the Food Bank of Navarre (Spain) avoids the annual waste of approximately 3,000 tonnes of food in good condition that can be consumed (Penalver et al., 2022). Penalver et al (2022) also pointed out that the carbon footprint is much smaller compared to the GHG emissions that would be produced without the FBN activity. The management of food through the FBN avoided the emission of 4568 and 4157 tonnes of CO_2e in 2018 and 2019, respectively (Penalver et al., 2022).

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Puig-Ventosa (2008) analysed the charging and pay-as-you-throw (PAYT) systems for waste management in Spain and concluded that the implementation of this type of system contributes to waste reduction, a fairer allocation of costs to users and more transparent financing of waste management. In the same vein, Aramyan et al.,(2016) highlights that this type of instrument offering negative incentives has been considered as a promising tool that can have a positive impact on the prevention and reduction of food waste. This is mainly due to the interest of chain actors in reducing food waste in order to pay less. This type of instrument could also stimulate the implementation of food waste prevention measures and the possibility of handing over food for donations (Aramyan et al., 2016).

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Task 2.1 Individual report

Evaluating the role of EU food policies in internalising environmental and social externalities: A literature review

Deliverable type	Month and date of delivery
Report	May 2023

Work package	Leader
WP2	INRAe

Dissemination level	Authors
Internal	Lukas Kornher, Yauheniya Shershunovich, Bezawit Beyene Chichaibelu

Programme	Contract Number	Duration	Start
Horizon Europe	101060481	48 Months	June 2022

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Preface

The EU as a whole is the largest importer and exporter of agri-food products in world. In 2022, the EU, as a whole, exported agri-food products with a value of 229 billion € and imported agri-food products with a value of 196 billion €. Since the United Kingdom left the EU, it is the EU's largest trade partner followed by the United States and China (for exports) and Brazil, Ukraine, and the United States for imports (Eurostat COMEXT 2023). The EU, however, is also the major trading partner of many low- and middle-income countries (LMICs), particularly in Africa, due to historic ties and the geographical proximity to Europe (Kornher and von Braun 2020).

Due to its importance in the global food system, EU internalization policies will also affect its trading partners, for instance by influencing the EU's import demand and export supply. Namely, EU internalization policies have negative social externalities on other countries if they harm EU imports from these countries. Therefore, in the following, we also consider the external effects of several major EU internalization policies. We identified four major EU policy areas that currently shape the EU's relationship with its trading partners. These are the Common Agricultural Policy (CAP), the Entry Price System (EPS), the EU's biofuel targets, and sanitary and phytosanitary food standards derived from various EU food safety regulations. More specifically, we look at the reformed post-2022 CAP policy and possible extensions as provided by the Farm-to-Fork strategy in the EU's Green Deal. We exclude general EU trade policies and trade agreements, since they are not explicitly derived from an internalization policy addressing environmental and social externalities as defined in the scope of this review. In addition to that, many LMICs are granted preferential and duty-free access to the EU market under the Everything but arms scheme for Least Developed Countries (LDCs) as well as bilateral and multilateral trade agreements, e.g. European Partnership Agreements (EPAs). The differences in these trade agreements make it also difficult to draw general conclusions on the external effects of EU trade policies.

Certainly, a number of other EU internalization policies do indirectly affect the EU's trading partners, but these policies are identified by the literature, for instance, Bureau and Swinnen (2018), as the EU main policies with consequences on LMICs, including poverty and food security, conflicting with the EU's development objectives. We include three more policies, that have not been formally adopted by the European Council and the European Parliament, but do exist as proposals or draft laws. These policies are included here, but will not be considered in the synthesis of the review. First, we consider the EU Regulation on deforestation-free supply chains, which was agreed upon by the European Parliament and the Council in December 2022. Second, we examine the external effects of the proposed EU Supply Chain Law on corporate sustainability obligations – the Corporate Sustainability Due Diligence Directive (CSDD), which the

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European Parliament passed on June 1st tightening the proposal from the EU Commission. Last, we evaluate the external dimension of the EU's Carbon Border Adjustment Mechanism, which will enter into force in its transitional phase as of 1 October 2023.

UBO's methodology

Based on the discussion among the WP partners, we decided to start the evaluation based on a systematic search of the impact literature on specific policy **instruments** within a specific **thematic area**. In our case, we focused on literature that considered the external effects of the policies on non-EU, mainly LMICs. Based on the overall scope of the FOODCoST project and through communication with the WP partners, we used the following search strings for the literature search:

#	Thematic areas		Proposed Keywords
1	Policy Region		"EU" OR "European Union" OR "Europ*"
2	Policy	Biofuel	"Biofuel$ penetration target" OR "Biofuel penetration target$" OR "Biofuel$ penetration" OR "Biofuel$ policy target" OR "Biofuel policy target$" OR "Biofuel$ directive" OR "Biofuel directive$" OR "Biofuel$ policy" OR "Biofuel polic*" OR "target$ on Biofuel" OR "target on Biofuel$" OR "penetration of biofuel$" OR ("Biofuel" AND "Greenhouse Gas intensity reduction target$") OR ("Biofuel" AND "GHG intensity reduction target$") OR ("Biofuel" AND "Greenhouse Gas emission$ intensity reduction target$") OR ("Biofuel" AND "GHG emission$ intensity reduction target$") OR ("Biofuel" AND "GHG reduction target") OR ("Biofuel" AND "Greenhouse Gas reduction target") OR ("Biofuel" AND "Polices to reduce Greenhouse gas emission") OR ("Biofuel" AND "Polices to reduce GHG") OR ("Biofuel" AND "Greenhouse Gas intensity reduction") OR ("Biofuel" AND "GHG intensity reduction") OR ("Biofuel" AND "Greenhouse Gas emissions") OR ("Biofuel" AND "GHG emissions") OR ("Biofuel" AND "GHG emission intensity reductions") OR ("Biofuel" AND "Greenhouse Gas emission intensity reductions") OR ("Biofuel" AND "GHG emissions target") OR ("Biofuel" AND "Greenhouse gas reduction-targets") OR ("Biofuel" AND "GHG reduction-targets") OR ("Biofuel" AND "Greenhouse gas emission reductions") OR ("Biofuel" AND "GHG emission reductions") OR ("Biofuel" AND "Greenhouse gas emission reductions")

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			OR (“Biofuel” AND “GHG emissions”) OR (“Biofuel” AND “Greenhouse gas emissions”) OR (“Biofuel” AND “GHG emission intensity”) OR (“Biofuel” AND “Greenhouse gas emission intensity”)
		Forestry	“Deforestation-free supply chain$” OR “supply chain$ free of deforestation” OR “Zero deforestation” OR “deforestation polic*” OR “regulation on deforestation-free supply chain$” OR “deforestation-free” OR “zero-deforestation supply chain polic*” OR “Zero-deforestation supply chain”
		Human rights	“Supply chain due diligence” OR “Due diligence” OR “Directive on due diligence” OR “Human right$ due diligence” OR “Due diligence directive$” OR “Due diligence polic*” OR “Due diligence obligation$” OR “Supply chain law$” OR “Supply chain act$” OR “Due diligence in supply chain$”
		CAP	“Common Agricultural Polic* post-202*” OR “post-202* Common Agricultural Polic*” OR “Post-202* CAP” OR “CAP post-202*” OR “CAP post 202*” OR “CAP 202*” OR “CAP Reform Post 202*” OR “CAP Reform Post-202*” OR “Common Agricultural Polic* after 2020” OR (“CAP” AND “Farm to Fork”) OR (“CAP” AND “Green Deal”) OR (“CAP” AND “direct payments”) OR (“CAP” AND “environmental goals”) OR (“CAP” AND “environmentally sustainable”) OR (“CAP” AND “agri-environmental subsidy”) OR (“CAP” AND “less favored area payment”) OR (“CAP” AND “pesticide limit”) OR (“CAP” AND “nitrogen limit”)
		Fair income	“Entry price system” OR “Entry-price system” OR “Entry price system for fruits and vegetables” OR “Entry-price system for fruits and vegetables” OR “EPS” OR “Entry price control” OR “Minimum price threshold” OR “Minimum entry price control”
		Food safety	“Food safety system” OR “Food safety Polic*” OR “Food safety” OR “Sanitary and Phytosanitary standard$” OR “Sanitary and phytosanitary measure$” OR “Maximum residue level$”

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			OR “Maximum residue limit$” OR “MRL” OR “Sanitary standard$” OR “Food safety standard$” OR “SPS$” OR “regulation on maximum residue level$” OR (maximum residue level$ in “pesticide$”) OR (maximum residue level$ in “ocharatoxin$”) OR (maximum residue level$ in “lead$”) OR (maximum residue level$ in “mycotoxin$”) OR (maximum residue level$ in “acrylamide$”) OR (maximum residue level$ in “veterinary medical product$”)
		Greenhouse gas emissions	“Carbon Border Adjustment Mechanism$” OR “Carbon border adjustment measure$” OR “Carbon Border Adjustment Polic*” OR “Carbon border measure$” OR “Carbon boarder restriction$” OR “Border Carbon Adjustment$” OR “Border tariff adjustment$” OR “Carbon pric*” OR “CBAM$” OR “CBA$”
3	Industry focus		“Food” OR “Agriculture” OR “Agricultural” OR “Agric*” OR “Agricult*” OR “Nutrition”

Instead of using the specific EU policy name or the regulation number, we opted for the common policy labels, e.g. Common Agricultural Policy instead of EU regulation 2021/2116 on the financing, management, and monitoring of the CAP.

The search was performed on Scopus and Web of Science first. However, the results were not satisfactory also because grey literature is not considered. Therefore, we performed another search in Google Scholar as instructed by the WP leader. As normal with Google Scholar, we obtained a large list of articles for each policy. We decided to consider articles written after 2000 (for the post-2022 CAP we focused on articles after 2020), which gave us about a maximum of 500 articles per policy. We then performed different strategies for the individual policies. If the number of articles was too large, we restricted the review to newer articles. For some policies, like the EU supply chain law on due diligence, we performed an additional customized search to make sure all relevant papers are included.

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1 THE ENVIRONMENTAL SPHERE

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Greenhouse gas emissions

1.1 Biofuel penetration targets/GHG intensity reduction targets

1.1.1 Introduction

In recent years, the environmental degradation due to greenhouse gas (GHG) emissions and volatility of oil prices have fostered many policy initiatives to promote alternative sources of energy in some developed countries (Williams and Kerr, 2016). Policies favoring biofuel production and consumption are adopted for the following reasons: (1) energy security – to decrease dependence on fossil fuels; (2) climate change mitigation – to reduce GHG emissions in the transportation; (3) farm income support – to stimulate demand for surplus agricultural crops (Fonseca et al., 2010).

With respect to energy security, biofuel production and consumption can reduce vulnerability due to energy price volatility, decrease dependence on foreign energy supply and possible supply disruptions (Fonseca et al., 2010). Nevertheless, it is heavily debated whether promoting biofuels rather than other forms of renewable energy is the best way to achieve energy security (Fonseca et al., 2010; Doornbosch and Steenblik, 2007). The potential of biofuels to contribute to GHG emissions reduction depends on a range of factors such as crop types, the amount and type of energy embedded in the fertilizer for growing the crop and in the usage of water, fertilizer production emissions, crop yields, the energy used for harvesting the feedstock and its transportation to refinery facilities, alternative land uses, the energy intensity of the conversion processes (IEA, 2006). Thus, different biofuel technologies have different GHG emissions reduction potential (fig. 1). For example, ethanol from sugarcane in Brazil has the highest estimates for the life-cycle GHG emissions reduction by up to 90% compared with the equivalent amount of gasoline. It is followed by ethanol from cellulosic feedstocks (70-90%) (Doornbosch and Steenblik, 2007).

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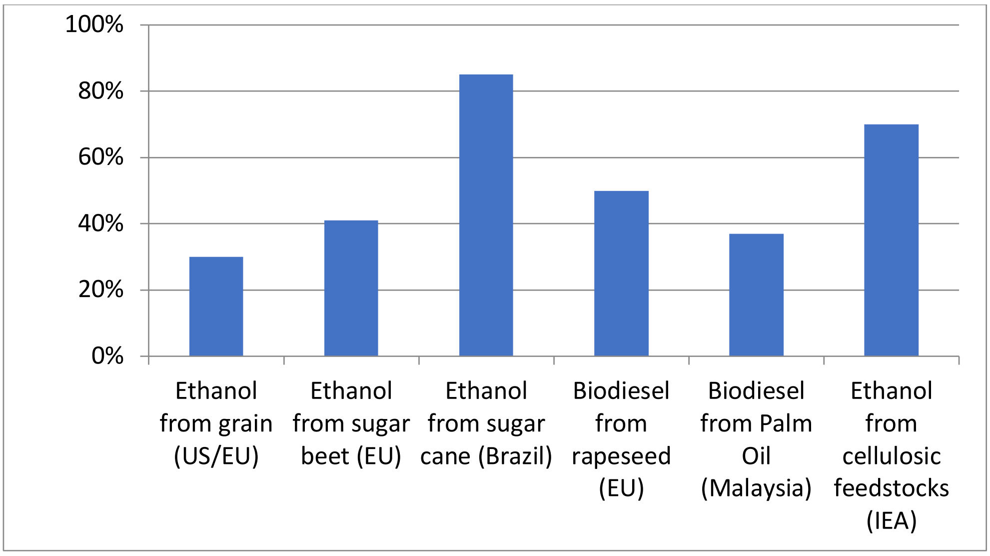
Figure 1: Range of estimated GHG emissions reductions from biofuels compared with gasoline and mineral diesel



Source: IEA, 2005; Zah et al., 2007 (biodiesel from palm oil).
Note: reduction in well-to-wheels CO2-equivalent GHG emissions per kilometer.

Biofuels are usually classified into:

1) first-generation biofuels. They are produced from biomass that is generally edible (rapeseed, sugar beet and cane, maize, cereals);
2) second-generation biofuels. They are produced from a wide range of different feedstocks like lignocellulose feedstock, municipal solid waste;
3) third-generation biofuels. They relate nowadays to biofuels from algae biomass but could to a certain degree also include usage of CO_2 as feedstock (Lee and Lavoie, 2013).

According to the comprehensive sustainability assessment of the first generation (sugar, starch) and second-generation (lignocellulosic, waste-based) bioethanol, both types of biofuel are beneficial for a feasible climate strategy, as long as their usage adhere to sustainability criteria (Dammer et al., 2017).

1.1.2 Description of the policy

On the way to making Europe climate-friendly, EU legislation with respect to biofuels has been undergoing changes in recent decades. These changes mostly relate to biofuel

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penetration targets / GHG intensity reduction targets and criteria for biofuel usage (table 1).

Table 1 : Overview of the EU legislation for biofuels

Policy name	Biofuel penetration targets / GHG intensity reduction targets	Criteria for biofuel usage
Directive 2003/30/EC (Original Fuel Quality Directive)	Biofuel penetration targets of 2% by the end of 2005 and 5.75% by the end of 2010 of all transport fossil fuels (petrol and diesel)	
Directive 2009/30/EC (Amended Fuel Quality Directive)	6% reduction of the EU-average level of life cycle GHG emissions per unit of energy from fossil fuels by the end of 2020 compared to 2010, obtained through the use of biofuels, alternative fuels and reductions in flaring and venting at production sites	Sustainability criteria for biofuels: GHG emission saving from the use of biofuels at least 35%; from 2017 – at least 50%; from 2018 – at least 60%; Biofuels shall not be made from raw materials obtained from land with high biodiversity value; from land with high carbon stock; from land that was peatland in January 2008
Renewable Energy Directive I (RED; 2009/28/EC)	Each Member State is to ensure at least 10% of all energy used in transport to be from renewable sources by 2020. Development of second- and third-generation biofuels	Sustainability criteria for biofuels: GHG emission saving from the use of biofuels should be at least 35%; from 2017 – at least 50%; from 2018 – at least 60%; Biofuels shall not be made from raw materials obtained from land with high biodiversity value; from land with high carbon stock; from land that was peatland in January 2008
Directive (EU) 2015/1513 (Indirect Land Use Change Directive)	To achieve 10% of all energy used in transport from renewable sources by 2020, each Member State should promote the consumption of advanced biofuels (such as those	Amendments to sustainability criteria in RED (2009/28/EC): GHG emission saving from the use of biofuels should be at least 60% for biofuels produced in installations that were launched after 5 October 2015;

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	made from waste and algae). Mandatory reporting of indirect land use changes emissions from biofuels traded	for installations that were in operation on or before 5 October 2015 the target is at least 35 % until 31 December 2017 and at least 50 % from 1 January 2018.
Renewable Energy Directive II (2018/2001)	32% of all energy usage in the EU, including at least 14% of all energy in road and rail transport fuels, is to be produced from renewable energy sources (RES) by 2030	Sustainability criteria for biofuels: biofuels produced from waste and residues obtained from agricultural land shall be considered only if there are monitoring and management plans in place to deal with the impacts on soil quality and carbon; biofuels shall not be made from raw materials obtained from land with high biodiversity value; from land with high carbon stock; from land that was peatland in January 2008; biofuels produced from forest biomass shall meet the criteria for minimizing the risk of using forest biomass obtained from unsustainable production; biofuels produced from forest biomass shall meet the criteria specified for land-use, land-use change and forestry; GHG emission from biofuels usage: at least 50% for biofuels consumed in the transport sector and produced in installations that were in operation on or before 5 October 2015; at least 60% for biofuels consumed in the transport sector and produced in installations in operation from 6 October 2015 until 31 December 2020; at least 65% for biofuels used in the transport sector and produced in installations in operation from 1

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		January 2021; at least 70% for electricity, heating and cooling generation from biomass fuels used in installations in operation from 1 January 2021 until 31 December 2025, and 80% for installation in operation from 1 January 2026
Proposal to 2018/2001, 2018/1999, and 98/70/EC COM/2021/557 final	The 14% target for renewable energy in transport is replaced with a 13% GHG intensity reduction target for transport for 2030	It strengthens REDII sustainability criteria by applying the existing land criteria (e.g. no-go areas) for agricultural biomass also to forest biomass and by applying the existing GHG saving thresholds for electricity, heating and cooling production from biomass fuels to existing installations (not only new installations)

It is evident from the EU legislative acts (table 1) that biofuel penetration targets / GHG intensity reduction targets have become larger in the course of years. Moreover, the sustainability criteria regarding the use of biofuels are getting stricter. The main benefits of such policy instruments as mandatory targets is that they create a more stable investment climate due to predictability of market shares (Fonseca et al., 2010).

1.1.3 Mechanisms of the instrument for internalization

The biofuel penetration targets are defined in terms of consumption (Padella et al., 2012), i.e. they incentivize both the EU production of biofuels and the import of biofuels to the EU to satisfy the increased demand. Kretschmer et al. (2009) employ the CGE model DART to assess the economic effects of the 10% biofuel target in the EU till 2020. According to the results, imposing this target causes a large expansion of the EU biofuel production. Moreover, introducing the 10% target for the EU as a whole should result in a more cost-effective allocation of biofuel production due to regional competitiveness defined by biofuel markups, input prices, and fossil fuel prices (Kretschmer et al., 2009). This implies that some EU countries will lower their production volumes while others will increase them relative to the policy scenario when there is a 10% target for each Member State (Kretschmer et al., 2009). Fonseca et al. (2010) also come to a similar conclusion that the EU biofuel policies can result in 2020 in significant cropping patterns changes within the EU. The production of cereals could be shifted away from Central and Central-Eastern Europe towards the North-Eastern, North-Western and Southern regions, while the production of oilseeds will increase in Eastern, Northern and Central

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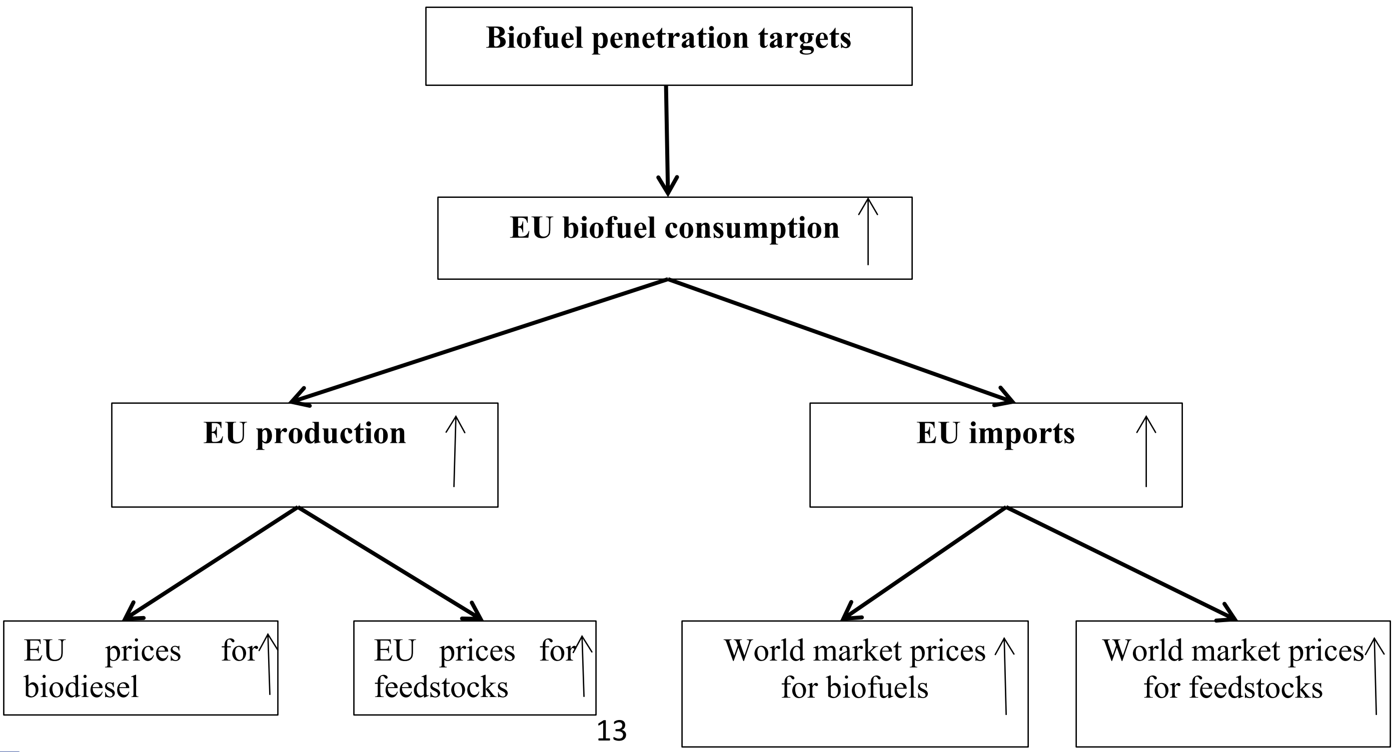
Western Europe (Fonseca et al., 2010). The expansion of the EU biofuel production will bring the increase of raw materials production and their prices (Padella et al., 2012). Padella et al. (2009) use a general equilibrium model, an extended version of the GTAP (Global Trade Analysis Project) model to analyze the EU biofuel policies effects in 2006-2015. The results show that oilseeds production in the EU rises significantly, at the same time other crops outputs decline (Padella et al., 2012). The biggest changes in prices in the EU from 2006 to 2015 occur in oilseeds and in biodiesel (Padella et al., 2012). As a result of the biofuel penetration targets, the EU exports of feedstocks (coarse grains, oilseeds) are reduced, while the increase in the imports in the oilseed sector makes up 81% (Padella et al., 2012). According to Kretschmer et al. (2009), thanks to the EU biofuel policies the Brazilian ethanol exports are diverted from the USA to the EU. Besides, the import of the Brazilian ethanol to the EU increases when the gasoline and diesel prices are higher in the EU and the overall fuel consumption is larger (Kretschmer et al., 2009). The increased EU demand for imported biofuels stimulate the world market prices for them (Fonseca et al., 2010). What concerns the effect on the world market prices for biofuels feedstocks, it is rather small for ethanol feedstocks, but larger for biodiesel feedstocks (Fonseca et al., 2010). This implies that the EU biofuel policies effect on the global food markets will be realized through vegetable oils rather than grains or sugar (Fonseca et al., 2010). Figure 2 shows the pathway of the biofuel penetration targets effects. Although the size of the effects differ depending on the commodity and the feedstock.

Figure 2: Pathway of biofuel penetration targets effects



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Source: Own illustration.

1.1.4 Policy impacts

1.1.4.1 Impact on final quantity produced and consumption

In 2003, 21% of the GHG emissions in the EU were generated in the transport sector, at that time biofuels accounted for about 0.6% of the total transport fuel (Commission of the European Communities, 2006). The Directive 2003/30/EC introduced a biofuel penetration target of 5.75% in transportation by 2010. The 2010 target of 5.75% was not reached by the EU, only Germany, France, Poland, Sweden, and Slovakia accomplished that goal (European Commission, 2013). Despite that fact, the Directive 2003/30/EC encouraged to a large extent biofuels production expansion (Williams and Kerr, 2011).

According to the Renewable Energy Directive I, 10% of all energy used in transport in each Member State shall be from renewable sources by 2020. In 2019, the energy from renewable sources accounted for 8.9% in transport activities in the EU-27 (in 2004 it was 1.6%). Sweden (30.3%), Finland (21.3%) and the Netherlands (12.5%) had the highest share of energy from renewable sources in transport fuel consumption (Zygierewicz and Sanz, 2021). In 2020, the share of energy from renewable sources in transport reached 10.2% in the EU, i.e. that the EU Member States achieved collectively the 10% target (EEA, 2022).

1.1.4.2 Impacts on externalities

The EU biofuel policies have a cascade of impacts in different spheres for developing countries. These impacts can be loosely classified into three groups: economic, societal and environmental.

1.1.4.2.1 Impacts on environmental externalities

Policies promoting biofuels production and consumption may have positive as well as negative environmental effects. Higher crop prices due to biofuels expansion may stimulate more intensive production methods, which result in more nitrate and phosphate leaching, pesticide contamination, loss of biodiversity, nitrous oxide emissions, soil degradation, and landscape deterioration (Fonseca et al., 2010). Williams and Kerr (2011) argue that the Directive 2003/30/EC had the unintended impacts of converting land used to produce food into the biofuels crop production. When taking into account indirect land use change, first-generation biofuels may result in a net increase of GHG emissions (Fonseca et al., 2010; Williams and Kerr, 2016). Williams et al. (2013) discuss the case how biofuel crop expansion threatens natural capital in

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developing countries, in particular in the Tana Delta in Kenya, which is home to rare sharks and reptiles and 350 species of birds.
Acccording to Rulli et al. (2016), in the case of biodiesel 59% of the water footprint and 80% of the land footprint were internal for the aggregate group EU27/OECD countries. The negative environmental effects with respect to biodiesel consumption in the EU are to a large extent associated with palm oil imports from Malaysia and Indonesia. A number of studies point at such impacts as large carbon emissions and high deforestation rates and threats to biodiversity because of palm oil plantations in Malaysia and Indonesia (Rulli et al., 2016; Carlson et al., 2012; United Nations Environment Programme, 2009; Fargione et al. 2008).
Edwards et al. (2010) compare the results from six economic models (AGLINK-COSIMO from OECD; CARD from FAPRI-ISU; IMPACT from IFPRI; G-TAP from Purdue University; LEI-TAP from LEI; CAPRI from LEI) to assess indirect land use change from increased biofuel demand in EU and US. According to the results, marginal extra ethanol demand in the EU results in the total estimated indirect land use change (ILUC) in the world from 223 to 743 kHa per Mtoe (million tons of oil equivalent), the largest share of which would occur outside the EU (Edwards et al., 2010). For the EU biodiesel scenarios, the range of the ILUC is between 242 and 1928 kHa per Mtoe**,** the largest share of which would also happen outside the EU. With respect to the extra palm oil demand, the ILUC is in the range from 103 to 425 kHa per Mtoe**.**

1.1.4.2.2 Impacts on social and health externalities

Biofuel production brings important societal implications that can be best examined through the energy-food-water nexus of biofuels (Rulli et al., 2016). Major staple crops like maize and wheat are used as feedstock for bioethanol production. For biodiesel the competition with food is partially alleviated through growing reliance on recycled cooking oil (Rulli et al., 2016). According to the estimations of Rulli et al. (2016), crops used to produce biofuel in 2013 would be sufficient to feed 280 million of people at the global scale, although it does not mean that this is the exact number of people whose access to food would be improved if biofuel use is reduced to zero.
Rising food prices due to the increased demand for biofuels bring the risks of food insecurity to the poorest food consumers in developing countries (Fonseca et al., 2010; Huang et al., 2012; Williams and Kerr, 2016). Rising food prices lead to the nutritional intake and caloric consumption decrease of the poor who are net food purchasers (World Bank, 2008; FAO, 2009).

1.1.4.2.3 Impacts on economic externalities

The EU biofuel policies stimulate the demand for biomass which in its turn can lead to increases in crop prices. Most studies on the impacts of biofuel production on food

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markets agree that the food prices rise was partially driven by expansion of biofuel demand (Fonseca et al., 2010). Rosegrant (2008) applied the partial equilibrium model (IMPACT) to assess the interactions between the agricultural commodity supply, demand and trade for 115 countries and the rest of the world. According to the results, higher biofuel production is responsible for 30% increases of the cereals price between 2000 and 2007. But the price effect depends on the commodity (Rosegrant, 2008). The biofuel initiatives, including the US and EU policies announced in 2008, would contribute to average wheat, coarse grain and vegetable oil prices increase by 7%, 10% and 35% respectively for the years 2013-2017 (OECD, 2008). The partial equilibrium model ESIM of the European agricultural sector (Banse and Grethe, 2008) till 2020 shows that the price level for crops in the EU would experience an increase by 1.7% due to the rise in the EU demand for biofuels, for the world market the positive impact on the prices would made up 2.2%. The results also show that meeting the 10% target of energy from renewable sources in transportation can only be accomplished by increase in imports of biofuels and biofuel inputs (80-87% extra biofuel demand) (Banse and Grethe, 2008).

Using a modification of the GTAP model, Huang et al. (2012) explores the impacts of the biofuels policies in the US, EU and Brazil on developing countries under the assumption of high future energy prices and high substitutability of petroleum-based fuels and biofuels. Through global markets the rise in feedstock prices predicted for the main biofuel production countries is transmitted to developing countries (Huang et al., 2012). It leads to the increase in the price of corn between 4.6% in West Africa and 8.1% in India (relative to the reference scenario in 2020). Higher corn prices lead to corn production expansion (from 2% in West Africa to 4.5% in South Africa). There is an increase in the self-sufficiency ratio for corn as a net result in developing countries (Huang et al., 2012). Rising prices for corn, sugar and rapeseed exert a spillover effect on prices of non-feedstock commodities in developing countries (wheat prices increase by 3.1% - 4.8%; rice prices – by 1.4% - 4.9%; meat prices – by 0.5% - 3.0%) (Huang et al., 2012). The biofuel production expansion under the assumption of high future energy prices and high substitutability positively affects value-added in the agricultural sectors. The agricultural value-added increment in developing countries is in the range from 3.2% in South Asia (excluding India) to 5.6% in South Africa (Huang et al., 2012). The largest benefits from the higher value-added are received by owners of land resources and unskilled and skilled laborers (Huang et al., 2012).

The sustainability criteria for biofuels introduced since 2009 (table 1) provide that biofuels are not produced from land with high biodiversity value; with high carbon stock; from land that was peatland in January 2008. They can be considered as capacity constraints or land specificity requirements aimed to prevent the natural capital loss and improve food security (Williams and Kerr, 2014; 2016). At the same time, they act as environmental non-tariff barriers for foreign suppliers of biofuels (Williams and Kerr,

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2016). The foreign suppliers of biofuels have to present the proof of compliance with sustainability criteria, which adds additional costs for them (Williams and Kerr, 2016). Moreover, ways to show the compliance with the land use criteria can include satellite images and maps, aerial photographs, land register databases and site surveys. These verification methods are not always present in developing countries and can constitute considerable costs for biofuel suppliers if they opt to hire experts from developed economies (Williams and Kerr, 2016).

Additionally, the EU renewable energy policy (RED I; RED II) which favors second- and third-generation biofuels is premised on technologies that have not reached their full commercialization either in developed or developing countries. Thus, the potential contribution that biofuel trade could make to the economic development in third countries would depend on the commercialization of these technologies (Williams and Kerr, 2016).

1.2 Carbon Border Adjustment Mechanism

1.2.1 Introduction

The EU established its Emissions Trading Scheme (ETS) in 2005 and nowadays it's the largest carbon market in the world (Titievskaia et al, 2023). This system sets a cap on the amount of GHG emissions that can be generated by the operators included in the system (European Commission, 2023). Emission allowances can be bought or received by operators which can trade them with one another if necessary (European Commission, 2023). The system incentives emissions reductions through market-based determination of prices (Titievskaia et al, 2023). There is a free allocation of allowances for sectors at risk of carbon leakage (Titievskaia et al, 2023). Carbon leakage takes place country's effors to reduce GHG emissions are offset by their increase in other countries as companies move their production to jurisdictions with less stringent environmental regulations. The emissions intensity of domestic production relative to other countries and exposure to international competition can influence the leakage rate (Matthews, 2022b). The EU Comission introduced a carbon border adjustment mechanism (CBAM) being included in the Green Deal to limit the carbon leakage.

1.2.2 Description of the policies

As part of the 'Fit for 55' legislation package designed to accomplish the EU's new greenhouse gas emission reduction target of 55% levels compared to 1990 by 2030, the European Commission (EC) put forward a proposal for a regulation establishing the CBAM on 14th July, 2021[1]. The mechanism aims to equalize the carbon price between

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52021PC0564.

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domestic and foreign producers by requiring exporters to the EU to pay a carbon price at the EU border equivalent to that of EU producers under the ETS (IEEP, 2021). The main goal of the CBAM is to prevent ‘carbon leakage’, guarantee a level playing-field between EU producers and third-country importers and encourage decarbonisation in global supply chains (IEEP, 2021).

Initially the EU commission has selected five industrial sectors (iron and steel, cement, fertilizers, aluminium, and electricity generation) to be covered by the CBAM due to their carbon leakage risk, emissions magnitude and for administrative feasibility (Titievskaia et al, 2023). In May, 2022 the ENVI[2] committee adopted the report to include hydrogen, organic chemicals and polymers to the CBAM scope and by 2030, all EU ETS sectors. Food and agriculture are not covered by the CBAM as most of the activity in this sector is not under the ETS, except for some food and drink processing plants (mainly those with dryers, boilers, furnaces and heating equipment units with a thermal input of more than 20 MW) (Matthews, 2022a). There is a certain possibility for introduction of a CBAM for food in the future as the EU Commission plans by December 2023 to carry out an assessment study for potential application of the polluter-pays principle to GHG emissions from agriculture (Matthews, 2022a).

During the transitional phase, 2023-2025, importers will have to report their embedded emissions of carbon dioxide (CO_2) and, if relevant, of nitrous oxide (N_2O) and perfluorocarbons (PFCs) without paying a financial adjustment (Titievskaia et al, 2023). At the end of the transitional phase, the EU Commission will decide on whether the scope of the CBAM should be further extended to indirect emissions and more products (Titievskaia et al, 2023). Starting from 2026, EU importers of products covered by the CBAM will have to get authorization from a CBAM authority and buy carbon certificates that correspond to the carbon price in the EU (Titievskaia et al, 2023).

The CBAM proposal[3] includes several exemptions:
Third countries that take part in the ETS and countries that have markets linked to the ETS;
If countries have comparable carbon prices, importers will be eligible for a reduction in the CBAM certificates amount to be surrendered which corresponds to the carbon price they have already paid in other jurisdictions;
If the electricity market in a third country is integrated with the EU market through market coupling, and a technical solution for the CBAM application to the electricity imports in the EU has not been found, electricity imports from this third country will be granted exemption, if certain conditions are met.

[2] The European Parliament’s Committee on Environment, Public Health and Food Safety.
[3] https://carbonmarketwatch.org/2021/12/16/a-brief-explanation-of-the-cbam-proposal/#embedded-emissions

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1.2.3 Mechanisms of the instruments for internalization

To ensure a level-playing field between the EU producers and exporters to the EU, the CBAM will act as an import tax for foreign producers willing to export to the EU. This import tax will be in the form of a carbon price for the goods covered by the CBAM. The price will be in accordance with that paid by the EU producers under the ETS so that domestic and foreign producers face the same conditions. The actual embedded emissions in the imported good will constitute the basis for the border levy and will have to be verified by accredited verifiers (Matthews, 2022b). The CBAM will function as a pass-through to prices mechanism and make exports from third-countries more expensive.

1.2.4 Policy impacts

1.2.4.1 Impact on final quantity produced and consumption

The CBAM creates a level playing field between EU and third-country producers by lifting prices of imported products by the carbon price EU producers face. This will increase EU production in comparisson to the situation where a carbon price is paid by EU producers, but not for imported products. However, the policy aims at re-establishing the situation – of relative competitiveness between domestic producers and foreign producers – from before the implementation of the EU carbon price. Therefore, we consider the policy neutral to the relative domestic (foreign) supply, though at absolute lower levels.

On the other hand, the carbon price will lead to lower consumption of emission-intensive products and to the substitution with products that are less emission-intensive. Since this is the consequence of the EU carbon price, and not of the CBAM, we do not consider this as a policy impact in this review.

1.2.4.2 Impact on externalities

1.2.4.2.1 Impacts on environmental externalities

According to the EU Commission impact assessment report, the CBAM will cause the decrease of the emissions in the sectors covered by 0.3% in the rest of the world relative to the baseline in 2030 (Titievskaia et al, 2023). The CBAM can potentially bring emissions reductions in third countries and encourage decarbonisation of their supply chains. Based on a CGE analysis of carbon adjustment for a developing country, Banerjee (2021) concludes that the closer the rates of domestic carbon adjustment measures and the border carbon adjustment, the higher the efficiency of carbon adjustment schemes

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in decreasing the emission intensity of energy use. The stricter carbon adjustment measures can stimulate emission-intensive productive sectors to switch to a lower-emission alternative (natural gas). On the whole, Banerjee (2021) recommends that for carbon adjustment measures to be effective in developing countries, they should be implemented as stricter as possible compared to the foreign standards. At the same time, energy-intensive sectors can be difficult and costly to decarbonize as they have long investment cycles (Wesseling et al., 2017).

At the same time, the introduction of the CBAM can stimulate third-country manufacturers to engage in 'resource reshuffling', i.e. if both cleaner and dirtier facilities are available in a country, a company might choose to reserve the lower emitting facility for exports, while using the dirtier facility to produce products for domestic or non-EU markets. In the end, 'resource reshuffling' can result in no change of the total emissions (Titievskaia et al, 2023; Hansen-Kuhn, 2021).

1.2.4.2.2 Impacts on social and health externalities

As the CBAM will increase the cost of exports from third-countries to the EU, it will have negative welfare effects for developing countries through the reduction of trade with them. Mattoo et al. (2013) model the impacts of different carbon-border tax schemes and conclude that the majority of them would exert a negative effect on exports from developing countries and their economic welfare.

1.2.4.2.3 Impacts on economic externalities

The CBAM can make exporting from third countries for the goods covered by it too costly and negatively affect their trade with the EU. Eicke et al. (2021) argue that the CBAM will unevenly affect countries around the globe. They conduct the quantitative analysis to map the countries according to their risks to the CBAM depending on their export structure, emissions intensity, emissions reduction targets, and the institutional capacity to monitor and report product-based emissions (Eicke et al., 2021). The findings reveal that countries with the highest relative risk are located in the Global South where institutional capacities to monitor and report emissions become one of the major obstacles and in non-EU Eastern Europe in which carbon lock-in and trade patterns play the key role (Eicke et al., 2021). Compliance with the CBAM would be associated with the increased transaction costs for third-country manufacturers. Producers could opt to either import through an EU customs broker or launch a business unit in the EU to function as a declarant for CBAM purposes (Titievskaia et al, 2023).

The introduction of the CBAM can have an indirect positive effect on the imports of food and agricultural products from third countries by making them more competitive in the

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European market. This is due to the inclusion of fertilizers under the CBAM and the exclusion of agricultural and food products. Copa and Cocega, the union of farmers and agri-business cooperatives in the EU, gives the following comment: “If the Carbon Border Adjustment Mechanism does not apply to agricultural products (which they would potentially support), it should not apply to fertilisers either. Nitrogen fertilisers are the most important input in crop production and the main variable cost item for our cereal and oilseed farms. However, the price of fertilisers is already higher in Europe than in the rest of the world because our fertiliser market is protected by customs duties and antidumping measures that cost European farmers €600 million a year. If a border adjustment mechanism were to be added to this, the price of fertilisers would skyrocket, further increasing the cost of agricultural production in Europe, while making the use of imported food more competitive and attractive.” (Hansen-Kuhn, 2021). Matthews (2022a) also indicates that the CBAM could exert an indirect effect on agriculture as agricultural activities depend on fossil fuel inputs such as fertilizers, pesticides, electricity and fuel. As the ETS allowance prices rise and the CBAM takes effect, the prices for these inputs will also increase, which can lead to decrease in the competitiveness of European agriculture and cause carbon leakage (Matthews, 2022a). This effect can take place only if agricultural products and food are not covered by the CBAM in the future.

The EU Commission is proposing to include maritime emissions in the EU ETS (CarbonBrief, 2021). For voyages between EU member states the existing EU ETS would be extended to cover 100% of maritime greenhouse gas emissions, for voyages from the EU and inbound ships arriving from the rest of the world, 50% of maritime greenhouse gas emissions would be included (CarbonBrief, 2021). The inclusion of 50% of maritime greenhouse gas emissions for shipping from third countries can increase the price of agricultural products imports and decrease their competitiveness in the EU market.

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Forestry

1.3 Deforestation-free supply chains

1.3.1 Introduction

Forests provide important goods and services including climate regulation and soil protection to the society (Ayoo, 2022). In several developing countries rapid deforestation is taking place causing loss of biodiversity, soil erosion, increased GHG emissions and the spread of zoonotic diseases like COVID-19 (Ayoo, 2022; Henn, 2021). International trade in agricultural commodities is a major driver of deforestation (Brandt et al., 2022). In 2001-2015 over a quarter of forest loss globally was due to commodity-driven agriculture, which means that these areas are unlikely to be forested again (Curtis et al., 2018; Ingram et al., 2020). Global agricultural trade, specifically for beef and vegetable oil (soy and palm oil), accounts for more than one billion tons of CO_2 emissions per year because of tropical forest loss (Pendrill et al., 2019). After China, the EU is the second largest export market for forest-risk commodities (TRASE, 2020) such as palm and soy oil, poultry, beef, leather, timber, rubber, cacao, maize and coffee. The EU is responsible for 10% of deforestation globally due to consumption of these products (European Commission, 2019).

1.3.2 Description of the policy

On 17 November, 2021 the EU Commission submitted the proposal for the EU deforestation-free regulation (European Commission, 2021a). On 6 December, 2022 a provisional political agreement on the regulation was reached by the European Parliament and Council. The deforestation-free regulation still has to be formally adopted by the European Parliament and Council and after that it has to be incorporated by the EU Member States into their national laws (KPMG, 2023). The main aim of the regulation is to guarantee that products placed on the EU market do not contribute to deforestation and forest degradation worldwide (European Commission, 2021a).

The new regulation sets mandatory due diligence requirements for companies that want to place forest-risk commodities on the EU market or export them. It covers seven specific commodities (palm oil, cattle, timber, coffee, cocoa, rubber, soy), their derivatives and also products made with the use of these commodities (e.g., leather, cosmetics, chocolate)[4] (Council of the EU, 2022). Operators and traders of these commodities will have to prove that the products are both:

[4] In the future additional products could be added to this list (Council of the EU, 2022).

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deforestation-free (produced on land that was not subject to deforestation after 31 December 2020) legal (compliant with all relevant applicable laws in force in the country of production).

Due diligence requirements differ with respect to company size and the country of origin of the commodity. Small and medium-sized enterprises are obliged to provide information on the sources of their products and raw materials and their suppliers (step one of the due diligence process). Large companies shall perform an additional risk assessment (step two of the due diligence process). If there exists a non-negligible risk according to the risk assessment, mitigation measures shall be taken by the companies (step three of the due diligence process) (Brandt, K., 2022). Countries of origin and their level of risk for deforestation and forest degradation are proposed by the EU Commission to be assessed on the basis of a benchmarking system. If commodities placed on the EU market are from a low-risk country, enterprises will have to conduct a simplified due diligence without performing risk assessment and mitigation steps (Brandt, K., 2022).

Competent authorities shall control the compliance with due diligence requirements. The number and type of controls will depend on company size (Brandt, K., 2022). The EU Member States would decide on penalties for non-compliance, which could include fines, confiscation of the commodities concerned or relevant revenues gained, temporary exclusion from public procurement processes (Hallelux, 2023).

1.3.3 Mechanisms of the instruments for internalization

The due diligence approach is the central pillar of the EU deforestation-free regulation. The due diligence concept was first introduced in 2011 in the United Nations nonbinding Guiding Principles on Business and Human Rights (UNGPs) (Henn, 2021). Since then it has been adopted into various other standards and regulatory initiatives at national and international levels (Henn, 2021). Due diligence obligations of market actors allow governments to deal with complex trade settings having various actors and generally weak transparency with respect to global supply chains (Henn, 2021).

For the EU companies mandatory due diligence requirements act as an administrative instrument. To satisfy them companies will have to adopt and maintain a management system (Fig. 3) aimed at identifying and reducing actual or potential risks and damages in their supply chains (Henn, 2021). Due diligence requirements are designed to affect processes and production methods applied in the country in which harvesting, extraction, and processing of forest-risk commodities take place. Usually these processes and production methods do not influence the physical characteristics of the product but target externalized production costs and the behavior of actors beyond their own borders (Henn, 2021).

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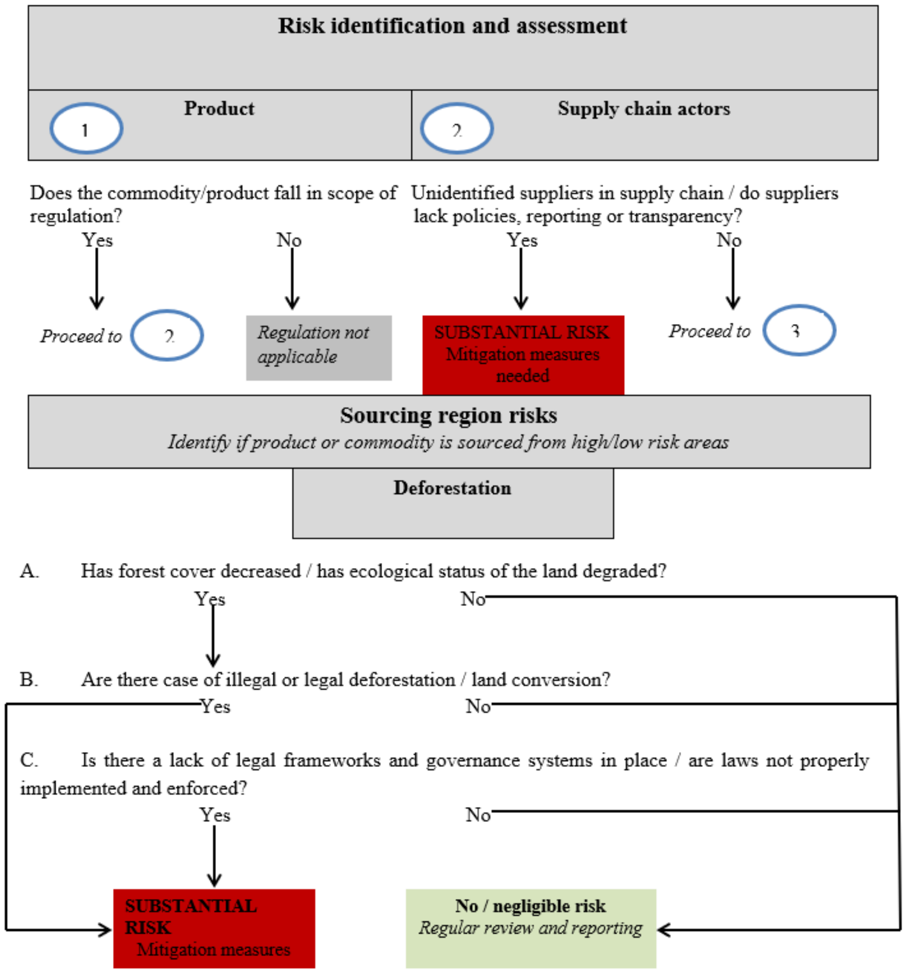
For the non-EU companies due diligence requirements will act as a demand-driven market-based standard. The EU Member States choose not to consume deforestation-risk products. Production countries can choose whether to comply with this standard or not. The financial incentive for compliance for production countries is the access to the EU market. Certification schemes and consumer campaigns represent similar demand-driven measures (Garcia and Pauwells, 2022).

Figure 3 **:** Example framework outlining the potential steps in a due diligence process to identify and assess specific risks on deforestation



Source: Adapted from Wood et al. (2021).

1.3.4 Policy impacts

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As the EU deforestation-free regulation has still not been implemented, only its potential impacts will be discussed in the subsequent sections.

1.3.4.1 Impact on final quantity produced and consumption

The expected impact of the EU deforestation-free regulation is to prevent the EU-driven deforestation in the amount of well above 71 920 hectares of forest per year by 2030, which would translate into an annual reduction of at least 31.9 million metric tons of CO_2 emissions to the atmosphere. Besides, the regulation is expected to significantly contribute to protecting biodiversity (European Commission, 2021b).

1.3.4.2 Impacts on externalities

1.3.4.2.1 Impacts on environmental externalities

Due diligence requirements can potentially create environmental externalities through leakage and spillover effects (e.g., to other ecological systems or geographical regions). Below there are a few examples how the EU deforestation-free regulation enables that to happen.

Implementation of the EU deforestation-free could potentially lead to EU trade shifts from high-risk producer countries to low-risk producer countries. This could result into a leakage effect if low-risk producer countries have weaker regulations and sell products sourced from high-risk producer countries to the EU market under false declarations (Brandt et al., 2022).

The cut-off date to define products as deforestation-free of 31 December 2020[5] has been chosen to minimize international supply chains disruption (KPMG, 2023). This cut-off still enables that soy production for the EU takes place on former pasture areas (Brandt et al., 2022). It means that pasture areas could be replaced with soy production, while cattle farming for non-EU markets could still be moved to forest areas resulting into new deforestation activities in developing countries (Brandt et al., 2022).

Another environmental risk consists in the possibility of production being shifted to other kinds of wooden habitats like savannahs and scrubland not addressed by the EU deforestation regulation (KPMG, 2023).

1.3.4.2.2 Impacts on social and health externalities

[5] They shall be produced on land that was not subject to deforestation after 31 December 2020.

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The measures proposed in the EU deforestation-free regulation can have unintended negative effects on the life of vulnerable groups in third countries such as smallholders, indigenous peoples and local communities who play an important role in forest conservation in tropical countries (Zhunosova et al., 2022). About 500 million farmers globally manage farm area of less than 2 ha (Lowder et al., 2016). The living conditions of such smallholders often depend on their integration in global supply chains (Dou et al., 2020). Zhunosova et al. (2022) discuss the following externalities that the compliance with the due diligence requirements of the EU deforestation-free regulation can cause to smallholders, indigenous peoples and local communities: their exclusion from high-value supply chains of goods under the regulation, inadequate price premiums to cover the cost of compliance, increase in the risk of land conflicts between large-scale producers and smallholders, displacement of smallholders, indigenous peoples and local communities to marginal lands. The cut-off date is the only measure currently incorporated in the proposal for the EU deforestation-free regulation to decrease the number of smallholders affected (Zhunosova et al., 2022). Institute for European Environmental Policy (2022) also argues that due diligence requirements will act as market entry barriers for smallholders who do not possess the necessary technological and financial means for compliance.

1.3.4.2.3 Impacts on economic externalities

The studies identified through the systematic review did not examine economic externalities.

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2 SOCIAL SPHERE

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Fair income

The EU has implemented several agricultural policies that aim at increasing and stabilizing farm incomes in support of broader policy objectives. The EU specifies the following objectives CAP by safeguarding farmers “to make a reasonable living” relation[6]:

- support farmers and improve agricultural productivity, ensuring a stable supply of affordable food; [Food security]
- maintain rural areas and landscapes across the EU; [Landscape conservations]
- keep the rural economy alive by promoting jobs in farming, agri-food industries and associated sectors. [Rural economy support and diversification]

2.1 Post-2022 CAP and Farm-to-fork strategy

2.1.1 Introduction

Prior to its fundamental reform in 2003, the CAP included direct market interventions in the form of support prices and quantitative production limits. The changes have reduced market involvement to a minimum and substituted production-linked subsidy by decoupling income support (related to the area under cultivation). The percentage of financial assistance for farmers, that the OECD calculates, has decreased from about 35% to 20% since 2000 as shown in Figure 4. As a result, the CAP is significantly less market-distorting than before the reform (Kornher and von Braun 2020).

[6] EU Commission (accessed May 2023) https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en

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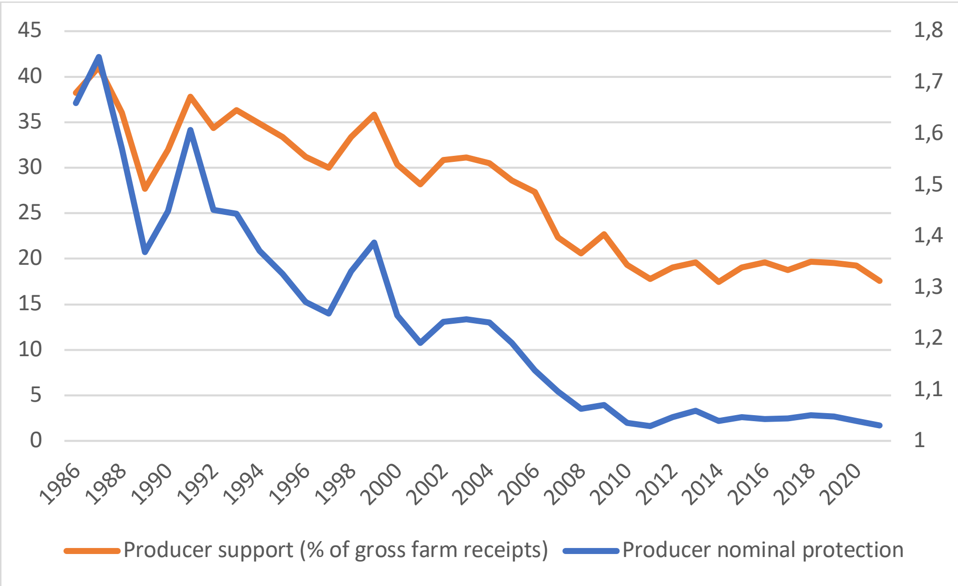
Figure 4: Development of EU overall producer support



Source: OECD (2023).

While initially, the CAP addressed mostly social externalities and aimed at increasing farm income, the reforms have been gradually integrated into environmental objectives. Agri-environmental programs were generalized for all member states in 1992. Before the greening premium, which farmers receive for maintaining permanent grassland, greater crop diversification and rotation, and for keeping "ecological focus areas" on arable land was introduced with the 2014-2020 CAP, since 2003 direct payments are linked to the application of best agricultural and environmental practices. However, the environmental performance of the CAP until 2020 has been widely criticized (Pe’er et al. 2017).

In June 2018, the European Commission presented the draft legislation on the future of the CAP for the period after 2020. Due to the Covid-19 pandemic and ongoing negotiations, the reform was postponed until after 2022 with the old rules applying for the transitory period. Before the post-2022 was agreed on and legally implemented, the European Commission and the European Parliament approved the European Green Deal including several policy measures to achieve the EU’s climate neutrality in 2050. The European Green Deal proposes a variety of policy initiatives and measures, many of which are pertinent to agri-food systems. The Farm to Fork Strategy, which aims to make the EU food system a "gold standard of sustainability", is undoubtedly the policy that directly affects the agriculture and food industry. However, many other policies also have an impact on the industry, including those related to the circular bio-economy, climate change, and biodiversity. The F2F strategy sets ambitious goals to be reached by

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2030 and that mainly concern farmers as the principal actors of the sustainability transition in agriculture. The main targets to be reached within 2030 are:

- 50% cut in the use and risk of chemical pesticides and in the use of more hazardous pesticides,
- 20% at least reduced use of fertilizers,
- 50% cut of EU sales of antimicrobials for farmed animals and in aquaculture
- 25% at least of the organically farmed area and a significant increase in organic aquaculture

The post-2022 CAP was formally adopted in December 2021. It will make European agriculture greener and more sustainable and provides a reliable and stable framework for the period up to 2027.

2.1.2 Description of the policy

The new post-2022 CAP for the period 2023-27 is governed by three regulations. These are Regulation (EU) 2021/2116, repealing Regulation (EU) 1306/2013 on the financing, management, and monitoring of the CAP; Regulation (EU) 2021/2115, establishing rules on support for national CAP strategic plans, and repealing Regulations (EU) 1305/2013 and 1307/2013, and Regulation (EU) 2021/2117, amending Regulation (EU) 1308/2013 on the common organization of the agricultural markets; Regulation (EU) No 1151/2012 on quality schemes for agricultural products; Regulation (EU) No 251/2014 on geographical indications for aromatized wine products; and Regulation (EU) No 228/2013 laying down measures for agriculture in the outermost regions of the EU (EU Commission 2023).
The CAP comes with a variety of different policy instruments, which also vary by member state. Generally, they can be classified into two pillars. First, direct payments that are granted to farmers - provided the respective requirements are met - per hectare of agricultural land. The second pillar includes targeted support programs for sustainable and environmentally friendly management and rural development. Enhancing cross-compliance and implementing eco-schemes are the key ways to strengthen environmental ambitions. The eco-schemes mobilize 25% of the CAP's Pillar 1 funds to support more ecologically and climatically responsible practices. The voluntary "organic schemes" now also receive payments. Pillar 2 measures remain very similar to those in the 2014–2020 CAP. The post-2022 also gives more independence to the member states in achieving the CAP objectives (BMEL 2023). According to Barral et al. (2023), the post-2022 CAP provides for measures to protect the environment and the climate, which is also observed in the national strategic plans of 15 member states.
However, several studies criticize that the design of the post-2022 CAP has not yet implemented the far-reaching objectives of the F2F and biodiversity strategies (Schebesta and Candel (2020) allowing a fundamental shift in the EU food system

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towards more sustainable and extensive agricultural production. In the following, we will not concentrate on individual policy instruments of the post-2022 CAP and the F2F strategy, but present evidence on the likely impacts of these policies on EU production and trade to assess the external effect of the reformed CAP. The specific policy scenarios assessed are therefore not always identical because the individual policy instruments are also significantly shaped by the national strategic plans of the members states, whose details are not yet certain.

2.1.3 Mechanisms of the instruments for internalization

The consequences of the CAP for food markets and producers in developing countries, especially before its fundamental reform in 2003 that decoupled support from production volumes, have long been the subject of debate. Coupled support instruments with variable levies, flexible tariffs, and export refunds, lifted EU producer prices above international prices and created incentives for overproduction in the EU, and led to an increase in EU agricultural exports (Bureau and Swinnen 2018). This causes the pass-through to prices in importing countries where domestic food production was displaced by cheaper imports from the EU (Borrell and Hubbard, 2000). Decoupled support does not directly incentivize production through increased marginal revenue, but has only indirect stabilization and (dis)investment effects on food production. For instance, decoupled payments can still alter behavior and market outcomes (Chambers and Voica, 2017). The pathway of external CAP effects is illustrated in Figure 5. Increased food imports result in lower prices for African consumers but hamper the competitiveness of local producers and create disincentives to invest in local production structures and supply chains—a possible reason for the increased food imports by African countries and the resulting import dependency (Rakotoarisoa et al., 2012). Food import dependency is often considered to have negative social externalities in LMICs with a large agricultural workforce.

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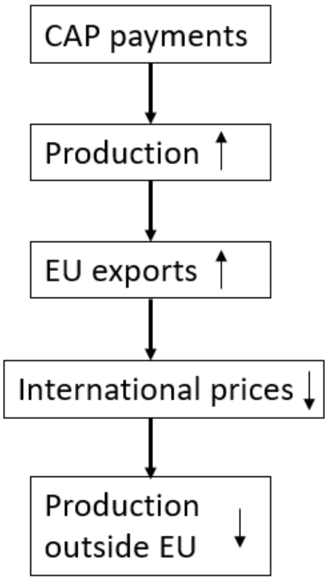
Figure 5: Pathway of CAP effects



The reform of the CAP may have significant impacts on the pathway of CAP effects if EU food production will respond and adjust to the new regulations. According to the studies reviewed, including an expert consultation carried out by Kornher and von Braun (2020), a stronger environmental and climate orientation of the CAP, will likely have a dampening effect on European agricultural production and subsequently on EU food exports. However, the effects are sector-specific depending on whether the EU is a net exporting or net importing country of the good. In addition, to understand the external effects of CAP policy changes on LMICs, we need to consider that the reduction in European exports could be also absorbed by other exporters, such as other OECD countries, resulting in largely unchanged production levels in LMICs.

2.1.4 Policy impacts

2.1.4.1 Impact on final quantity produced and consumption

As described above, there is ample evidence that the CAP has impacted EU food production in the past and continues to do so indirectly. Therefore, any regulation is expected to change the production and investment decision of EU agricultural producers. The ex-ante assessment of policy changes requires the use of simulation models. Both general and partial equilibrium models can be used, but partial equilibrium models, such as the Common Agricultural Policy Regionalized Impact (CAPRI) model, are usually advantageous due to their more detailed depiction of agricultural policies and heterogeneities in the EU farm structure. A systematic literature review on the F2F

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impacts identified the following studies summarized in Table 2. These studies model the F2F implementation diffently. Latka et al. (2021) model only moderate environmental restrictions. Henning et al. (2021) also run a scenario for a reduction of the nutrient surplus by 50% only instead of the full implementation.

Table 2: Study results on the impact of the post-2022/F2F strategy on agriculture production in % in the EU

Cereals	**Oilseeds**	**Fruits, vegetables, and permanent crops**	**Fodder crops**	**Beef meat**	**Dairy**	**Type of model**	**Author**
−15.0	−15.0	−12.0		−13.0	−10.0[d]	CAPRI	[1]
−48.5[a]	−60.7	−5.2[c]		−13.5	−11.6	GTAP	[2]
−18.0[a]						AGMEMOD	[3]
−21.5	−20	−13.0	−31.5	−20.5	−7.0	CAPRI	[4a]
−7	−4	−1.5	−27	−17	−6.0	CAPRI	[4b]
−26.0[a]	−24.0[b]					HFFA	[5]
−2.0	−1.0	−0.3[c]		−11.0[e]	−1.0	CAPRI	[6]

Source: Adapted from Wesseler (2022).
Note: [1] Barreiro-Hurle et al. (2021) [2] Beckman et al. (2021) [3] Bremmer et al. [4ab] Henning et al. (2021) [5] Noleppa et al. [6] Latka et al. (2021); [a] wheat only, [b] oilseed rape only, [c] F&V only, draw milk supply, [e] all meat. AGMEMOD is Agricultural Member State Modeling. HFFA is a multi-market partial equilibrium model.

All studies show a reduction in EU production in all sectors, which are strongest for cereals, oilseeds, and beef meat. The general equilibrium effects by Beckman et al. (2020) are much larger for cereals and oilseeds than for the partial equilibrium models. The results by Latka et al. (2021) using moderate scenarios do show relatively limited effects for cereals and oilseeds and comparable results for meat. These results are closer to the nutrient surplus-only scenario of Henning et al. (2021). In conclusion, the full implementation of the F2F will reduce EU food production significantly, however, the reform changes of the post-2022 CAP will likely not have strong effects on EU food production; except for fodder crops, meat, and dairy products.

A shortcoming of modelling approach is that direct payments have no effect on production as they are not affected varable input costs (they constitute a subsidy on the fixed input land). However, CAP direct payments, decopuled from production, act as incentives to increase production by safeguarding against uncertainty, i.e. decoupled payments increase farmers' welfare through certain income. First, the pertinent literature shows that direct payments may encourage risky investments into productivity-enhancing technologies by lowering their level of risk aversion. Second, by expanding the amount of available collateral, decoupled payments can overcome credit

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limits and positively impact output and investment (Kazukaskas et al., 2013). To sum up, decoupled direct payments may still matter because they decrease allocative inefficiency through "investment-induced productivity gains" (Rizov et al., 2014). Consequently, it is questionable to treat direct payments as completely decoupled from variable inputs in simulation modeling studies (Urban et al., 2016).

2.1.4.2 Impacts on externalities

2.1.4.2.1 Impacts on environmental externalities

Several studies examined the environmental impacts of the F2F strategy. Barreiro-Hurle et al. (2021), Henning et al. (2021), and Latka et al. (2021) evaluate the greenhouse gases (GHG) emissions. They report that the F2F will reduce the EU's GHG emissions between 20% and 35%. The major share comes from the reduction in fertilizer use. Latka et al. (2021) estimate a reduction of non-CO2 GHG emissions by 40%. However, leakage is significant. According to all these studies, more than half of the GHG emissions saved in the EU are leaked to the rest of the world. However, Henning et al. (2021) argue that the CAPRI model does not capture all leakage effects. For instance, the effect on forest lands cannot be explicitly modeled, and thus, the F2F could increase and not reduce global GHG emissions. In contrast, Noleppa and Cartsburg (2021) note that technological innovations, for instance in plant breeding, and more efficient input use could contribute to reductions in GHG emissions so that leakage effects may be substantially smaller.

2.1.4.2.2 Impacts on social and health externalities

As discussed, increased EU food production leads to an increase in EU exports of EU products. Next to processed foods, the EU currently exports mainly wheat, meat, and dairy products to LMICs (Kornher and von Braun, 2020). The modeling studies presented above show that EU production of these products could be significantly affected by the post-2022 CAP and the full implementation of the F2F strategy. In this presentation of the results, we focus on trade and production effects on Africa because Africa is the main importing region of meat and dairy products. Overall, the effects of the post-2022 CAP on Africa's dairy and meat production are moderate, while the effects on EU meat and dairy exports are significant (Table 3). This shows that Africa would substitute EU meat and dairy imports with imports from other regions, most likely Latin America. Hence, meat and dairy producers in these regions benefit from the CAP reform. Therefore, we conclude that the post-2022 CAP is likely to have small external social effects. However, the full implementation of the F2F strategy could have much stronger effects and coupled with innovations in Africa's agricultural sector lead to stronger external benefits (Kornher and von Braun, 2023).

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Table 3: Study results on the impact of the post-2022/F2F strategy on agriculture production in % in the EU

EU meat exports	EU dairy exports	Africa meat imports	Africa dairy production	Author
−70	+3	n.a.	n.a.	[1]
−21	−20.7 (−157)	−8	+3.2(1)	[2]
−70	−20	n.a.	n.a.	[4a]
−65	−6	−5	0	[6]

Source: Adapted from Kornher and von Braun (2023).
Note: [1] Barreiro-Hurle et al. (2021) [2] Beckman et al. (2020) [4a] Henning et al. (2021) [6] Latka et al. 2021.

In addition to that, there could be the concern that higher international food prices, as a consequence, of the F2F strategy have adverse implications for food security in importing regions. However, the studies of Beckman et al. (2020) and Latka et al. (2021) do not find significant effects on Africa's food security.

2.1.4.2.3 Impacts on economic externalities

The studies identified through the systematic review did not examine economic externalities.

2.2 Entry price system

2.2.1 Introduction

According to Eurostat Comext (2023), the EU fruit and vegetables (F&V) production is estimated at € 73.4 bil. in 2022. This represents about 14% of all EU agricultural production. However, the EU is traditionally a net importer of F&V due to unfavorable climatic conditions. EU F&V production, therefore, is also highly geographically concentrated in Spain and Italy, which account for close to 50% of fruit production and 40% of vegetables in the EU. Spain is the largest European F&V-producing country and showed less output variability than Italy and Greece in recent years.

As for intra-EU trade, exports for certain fruits and vegetables are often dominated by individual member states. For instance, Spain exports the majority of citrus fruit (64.4 % of the total value) melons and watermelons (53.7 %), apricots, cherries, and peaches (51.9 %) as well as lettuce and chicory (51.1 %) within the EU. The Netherlands has the largest share in tomatoes (45.5 %); and, Italy accounts for the highest share in intra-EU exports of apples and pears and quinces (29.9 %) (Di Cicco 2019).

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Table 4: EU's role in the global F&V sector in 2021

	EU share in global production	EU share in global imports	EU share in global exports	EU net trade-in billion USD	Share of intra-EU imports	Share of intra-EU exports
Fruits	**5%**	**36%**	**31%**	**-9.5**	**47%**	**80%**
Vegetables	**7%**	**40%**	**43%**	**3.3**	**78%**	**76%**

Source: Own illustration based on FAOSTAT (2023) and UNCTAD (2023).

The EU's role in the global F&V sector is significant, although slowly declining in the last decade. In 2009, the EU's share in world F&V production was still around 8.3%, which has declined to 5% in fruits and 7% in vegetables in 2021 (Table 4). This is mostly driven by a steady reduction in EU production, particularly of fruit (excl. citrus) (-10%) and vegetables (-5.5%), although the production of citrus fruit has increased (+12%) (FAOSTAT 2023). At the same time, F&V production in many other areas has increased, which led to the reduction of the EU's weight in world production. However, with regard to F&V trade, the EU's share is much larger than its share in global production (Table 4). The EU accounted for between 30%-43% of global fruits and vegetable imports and exports. It is important to note that, the EU is a net importer of fruits only and a net exporter of vegetable products. This is signified in intra-EU imports and exports of fruits and vegetables. For instance, about 50% of all EU fruit imports are sourced from outside the EU.

It has been shown that the EU F&V sector is characterized by relatively small-sized farms and, in 2007, more than 70% of the F&V farms were smaller than 5 ha. This poses limits to economies of scale and efficient production scale and reduces the international competitiveness of European F&V producers (Agrosynergie 2008). Producer prices have historically been volatile for fresh F&V and appear to be declining in trend in recent years. In addition to that, the retail sector in the EU is dominated by a few large suppliers in the upstream stages of supply chains. How to participate in contemporary EU-based chains where the retail stage coordinates the other actors is the main challenge for small F&V farmers, whether they are from the EU or other supplying areas. Additional supply for fruits and vegetables is mainly sourced from the Mediterranean area, but also from Central-South America and some African countries, while Central and South America and Africa export mainly tropical fruits, Mediterranean countries for some F&V products (Romdhani & Thabet 2017).

To protect European F&V producers constitutes a complex import regime for fresh fruit and vegetables (F&V) that is product and country-specific and subject to seasonal adjustments. The complexity is due to the EU's role as a major F&V importer and

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producer at the same time with conflicting interests to safeguard EU F&V producers and guarantee the supply of differentiated
F&V products to EU consumers at reasonable prices. The main objective of the Entry Price System (EPS) is, however, the protection and stabilization of producer revenues in the EU and shielding these producers from international competition (Goetz and Grethe 2009; Agrosynergie 2008).

2.2.2 Description of the policy

The Council Regulation No. 1035/72 on the common organization of the fruit and vegetable (F&V) market codified the fundamental rules governing the F&V market's organization and contained a number of distinct regulations that were created at various times and amended several times after their adoption. The Regulation identified the production of fruits and vegetables as a significant source of agricultural revenue and stated that one important goal must be the creation of a balance between supply and demand at fair prices to the producer, taking into consideration international commerce.

A main instrument of the Regulation No. 1035/72 is the EPS to stabilize the common market by preventing the price levels in *non-EU* countries to undercut the EU price. The EPS establishes a minimum import price of 15 fresh fruits and vegetables listed products above which the price of imported produce should remain. Below these thresholds, the EPS applies and extra duty in addition to the ad valorem import tariffs that apply for the respective trade partner. The periods in which the regulations apply vary across the products covered by the regulation.

The problem associated with the EPS is the determination of the price threshold and the trigger entry price, which determines whether the EPS applies or not. To determine the import price is complicated because a large share of F&V products is paid on commission in the EU and the price is only determined when the products are sold in the EU (Goetz and Grethe 2009). For this reason, the EU calculates a market survey-based ‘synthetic’ import price, which the Commission refers to as the standard import values (SIVs) for each product and export origin, collated less the marketing costs, transportation costs, and customs duties (Kareem et al. 2016). The procedure is described in the earlier EC Regulation 3223/94 designed for the reference price system (RPS), the predecessor of the EPS. In case the SIV for a specific export country and the product is below 92% of the trigger entry price, the specific duty applied is added to the import prices on top of the tariff is the maximum tariff equivalent. The EPS was compared to the Japanese Gate Price System for pork (Santeramo et al. 2019). In a way, the EPS contradicts the rules stated in several preferential trade agreements the EU has concluded. Therefore, the EU has included concessions for the listed fresh F&V products in these trade agreements, particularly with the Mediterranean Countries (SEMC).

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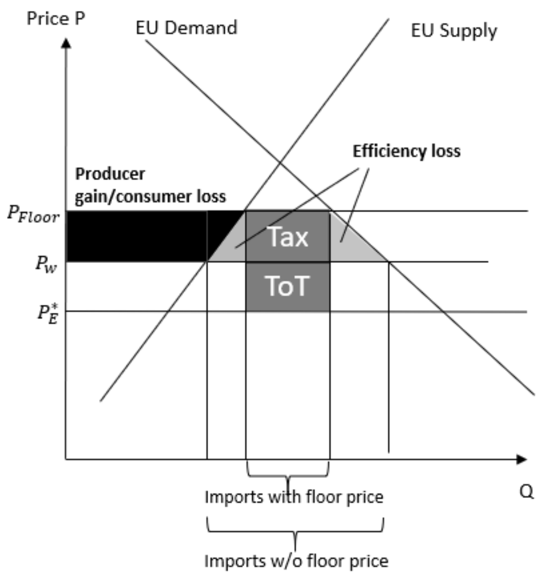
2.2.3 Mechanisms of the instruments for internalization

The mechanism of internalization follows standard microeconomic theory. In a closed economy, the floor price is set above the equilibrium price to increase the price producers receive. In an open economy, the price is determined in the international market and lies below the autarkic equilibrium price. By setting a floor price above the free-market international price, the EPS is equivalent to an (additional) import duty. The EPS-determined floor price, above the equilibrium price, even if is below the autarkic equilibrium price still protects and benefits producers. This leads to additional domestic production incentives and fewer imports. As a result, consumer surplus is transferred to producer surplus, but also at the expense of deadweight loss (Figure 6).

The exact impact of the EPS depends on the price responsiveness of demand and supply; the slope of the demand and supply curves. The reduction in consumption will be lower if consumers are unresponsive (inelastic). In the autarkic situation, unresponsive demand increases the producer surplus. In an open economy, the price responsiveness of demand will only determine the import demand and does not affect the producer surplus. On the other hand, in an open economy, domestic production and gains in producer surplus increase the price responsiveness of supply.

Figure 6: Effect of the EPS equilibrium prices and quantity



Both demand and supply tend to be inelastic. Agricultural supply response, especially for peri-annual goods such as several fruits, will be lagged as trees need to grow to carry fruits. Therefore, small increases in price are expected to have little negative effects on

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the quantity and the deadweight loss. In addition to the short-term effects, the floor price for producers has also long-run structural effects. The price stabilizing effect of the EPS incentive domestic production and investment in technologies by reducing price risk. This will also keep less efficient producers in the market. Therefore, the EPS could have an effect on the market structure and overall resource efficiency in the F&V sector (Agrosynergie 2008).

2.2.4 Policy impacts

2.2.4.1 Impact on final quantity produced and consumption

To understand the EPS effects on trade, we first discuss the effectivess of the policy to alter EU food production. The effectiveness of the EPS has been subject to several studies over the past years. Most of these studies focus on selected F&V products and sometimes also selected EU trading partners. The studies reviewed for this analysis mostly focus on the EU price of imported products instead of the domestic production quantity as the outcome variable. In the following, we infer that a positive effect of the EPS on EU prices for the studied commodities leads to positive domestic production effects and lower imports. Higher prices and lower imports reduce consumption.

Goetz and Grethe (2009) examine the relevance of the EPS for a number of F&V products under the EPS and for the major exporting countries. The authors look at the difference between the import price and the trigger price to compare the frequency and magnitude of import prices being below the trigger price between 1995-2005. Among the different product-exporter pairs, they observe heterogeneity in the relevance of the EPS. For artichokes, courgettes, cucumbers, lemons, plums, and tomatoes the frequency of low import prices and or the magnitude of the price difference were large. The effectiveness of the EPS on apples, clementines, and pears was lower, and lowest for apricots, mandarins, oranges, peaches and nectarines, and table grapes. Generally, the EPS influence was the greatest on E-neighboring countries and lower for far-away countries except for China and South Africa (Goetz and Grethe 2010).

Cioffi et al. (2011) employ time series econometrics to test how the EPS affected the EU price of tomatoes and lemons. Specifically, they test if the EU price determination is characterized by non-linearities around the 92%-trigger price threshold. Overall, this econometric approach shows that the EPS has an impact on EU tomato and lemon price dynamics. This is shown by the fact that when import prices are below the trigger prices, the price determination process of tomatoes and lemons is independent of the import price. The pattern is different when import prices are greater than the threshold. In this case, EU prices are correlated with import prices. This is indicative of an insulating role of the EPS for EU prices for these two products. However, this is not the case for all exporting countries, possibly because EU trade volumes differ across partners.

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The study by Santeramo and Cioffi (2012) validates the two earlier works. First, they show that exporters tend to offer their products above the trigger price threshold to avoid the punitive tariff. In other words, the EPS does not intervene most of the time as shown by Goetz and Grethe (2009). On the other hand, in four out of five cases – the exemption being lemons from Argentina – the EPS causes non-linearities around 92% of the trigger price. However, only in two of these four cases (tomato from Turkey and Morocco) the EPS successfully insulates EU prices by pushing import prices below the threshold. Therefore, the authors conclude that "the main effect of the Entry Price Regime is likely to be the limitation of low-priced imports" (Santeramo and Cioffi, 2012, p. 700).

The study by Garcia-Alvarez-Coque et al. (2009) employs a partial equilibrium model to examine the EPS effect on imports of tomatoes, cucumbers, clementines, and table grapes. The simulation results show that for most of the reference period, the EPS had hardly any influence on EU prices as the import price of these cucumbers, clementines, and table grapes, were primarily above the respective trigger price. On the other hand, the EU tomato price was often below the EPS. Hence, the EPS likely had positive domestic production effects for cucumbers and tomatoes from specific origins and seasons, particularly in Morocco and Israel. These effects are concentrated in specific seasons and do not apply all year round. Therefore, the EPS could be significantly lower in several parts of the year without affecting EU domestic production.

2.2.4.2 Impacts on externalities

2.2.4.2.1 Impacts on environmental externalities

The studies identified through the systematic review did not examine environmental externalities.

2.2.4.2.2 Impacts on social and health externalities in non-EU countries

The results from above on the effectiveness of the EPS to stabilize EU prices, and incentive production, already give an indication of its effect on F&V exports to the EU market. In summary, these papers find only moderate stabilization effects of the EPS on EU prices. They, however, note that for some products, the EPS insulates EU prices and acts as a barrier to low-priced exports, particularly tomatoes. There are also studies that focus specifically on the EPS effects on exporting countries.

Kareem et al. (2017) analyze the relevance of the EPS and the EU's food safety standards for African agri-food exports, specifically the likelihood of an exporting activity (extensive margin). They find that the EPS had no effect on African exporters of oranges

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and limes and lemons; although the t-value for lime and lemon is also relatively large but not significant at conventional levels of significance. The authors identify a reducing influence on their probability of exporting tomatoes to the EU between 2008 and 2013. In a related paper, they also find a negative and significant effect on the level of tomato trade (Kareem et al. 2015).

Another study by Romdhani and Thabet (2017) examines how Tunisian export opportunities to the EU are impaired by the EPS. They use a partial equilibrium model for Tunisia, the EU, and the Rest of the World (RoW) to simulate the potential consequences of opening up the EU F&V market, particularly removing the EPS. The results suggest that exports to the EU, from both Tunisia and the RoW, would significantly increase without import duties and the EPS. For oranges, they observe only an increase in exports from the RoW to the EU without specifying which exporting country would benefit. At the same time, intra-EU trade would decrease by only 0.1% (peaches) and about 1% (tomatoes). Impacts in general also concentrate on specific periods that previously were affected by the EPS.

The most comprehensive analysis of the EPS impacts on the EU's F&V imports is Santeramo et al. (2019). The authors look at trade flows from major EU trade partners of apples, lemons, oranges, peaches, pears, table grapes, and tomatoes. They employ an econometric structural gravity model approach using different indicators of the frequency and the extent of EPS interventions during the period from January 2000 to December 2014. Overall, both the frequency of import price shortfalls below the trigger price and the magnitude of these shortfalls are significantly negatively related to the trade flows to the EU. This is the case for six out of seven products, but surprisingly not for tomatoes. The variability of import prices, representing the uncertainty of an EPS intervention, is negatively associated with trade flows for all products. This shows that the EPS is effective in protecting F&V imports from non-EU countries. In other words, the EPS has negative effects on F&V exports to the EU.

In summary, there is mixed evidence on the effectiveness of the EPS to stabilize EU prices. In detail, the results of the reviewed studies suggest that the EPS is effective for some products and not for others. The effectiveness of the EPS to stabilize EU prices has an impact on F&V imports to the EU as shown by Santeramo et al. (2019). The EPS seems to be most relevant for Mediterranean F&V exporters. Most studies agree that the EPS has a strong influence on the import price of tomatoes to the EU. However, the reviewed studies that focus on the EPS impact on prices neglect the structural role of the EPS for F&V exporters. The existence of the EPS and the risk of reduced profits from capped prices may prevent F&V producers and exporters to enter the market. The results by Santeramo et al. (2019) on the relevance of the variability of the import price support the relevance of the negative structural effects of the EPS.

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2.2.4.2.3 Impacts on economic externalities

Agrosynergie (2008) also examines how the EPS affected the competitiveness of the EU as F&V producers. During the observation period, the EU's share in global F&V production and exports of products included in the EPS has declined. On the contrary, the share of some F&V products, not covered by the EPS, has seen growth in production and exports. This may give rise to the concern that the EPS creates incentives for less efficient producers to remain in the market. However, this needs further attention in empirical studies.

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Human rights

2.3 Corporate Social Responsibility Due Diligence

2.3.1 Introduction

The most recent Global Estimates of Modern Slavery estimates that 50 million people were victims of one or more forms of modern slavery in 2021, appointing to the upward trajectory of this problem. Of the 50 million, about 28 million were engaged in forced labor and about 12 million were children (Walk Free, 2023). Child labor is also still a persistent reality in the modern world today. According to UNICEF and ILO (2021), 160 million children, including 63 million girls and 97 million boys, or nearly 1 in 10 of all children globally, were child laborers as of the beginning of 2020. Agriculture remains the primary industry that employs child labor. 70% of the 160 million children are employed in agriculture. More than 75 percent of all 5 to 11-year-olds engaged in child labor are employed in agriculture (UNICEF & ILO, 2021). These figures serve as a sobering reminder that despite a clear international commitment in the United Nations Sustainable Development Goals, decent work is still a dream for hundreds of millions of people around the world (European Commission, 2022a).
At the same time, global supply chains and business networks have expanded along with the processes of economic globalization. While the expansion of global supply chains has unquestionably benefited developing nations greatly, it has also had some unfavorable effects, such as abuses of human and labor rights, child labor and forced labor, harm to the environment, and corruption (Nelson, Martin-Ortega, & Flint, 2020). Global supply chains account for nearly two-thirds of all occurrences of forced labor with employees being exploited in numerous industries and at every stage of the supply chain. However, due to their complexity, it is particularly challenging to determine the origin of products and the presence of forced labor in many of these supply chains (Walk Free, 2023). According to Murray and Lenzen (2010), a product's operational and supply chain impacts collectively make up its overall impact or footprint, from the consumer's point of view. Therefore, even if an organization's activities may be free of forced labor, exploitation might be concealed in the upstream layers of its supply chain (Gold et al., 2015; Shilling, Wiedmann, & Malik, 2021).
Up until now, the favored strategy for encouraging global companies to take charge of their supply chains has been centered on voluntary action. It was anticipated that global companies would voluntarily carry out due diligence in order to protect their reputations and enhance their status with employees and clients. Hence, a number of international frameworks have been formed as guidelines to urge multinational corporations to prevent harm to human rights and, when it does happen, to minimize and redress it (Nelson, Martin-Ortega, & Flint, 2020; European Commission, 2022b). One such framework is the Guiding Principles on Business and Human Rights (UNGPs) which was unanimously endorsed by the United Nations Human Rights Council in 2011, creating

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the first important international framework outlining the obligations and responsibilities of governments and business enterprises to prevent, address, and remedy the impacts of globalized business activity on human rights (UN, 2011; Roos, 2013). The UNGPs introduced the concept of due diligence, to "identify, prevent, mitigate and account for" adverse corporate impacts on human rights and the environment, and the OECD Guidelines for Multinational Enterprises incorporated it to extend to other areas of responsible business conduct such as the environment and climate change, conflict, labor rights, and bribery (Smit et al., 2020b). Evidence, however, points to the need for statutory environmental and human rights due diligence laws to address human rights violations in supply chains and the insufficiency of the voluntary approach (Nelson, Martin-Ortega, & Flint, 2020; McCorquodale & Nolan, 2021; European Commission, 2022b).

The regulatory environment is currently undergoing significant change. Governments are passing laws to enact mandatory human rights and environmental due diligence laws, such as those recently adopted in France, the French Duty of Vigilance Act 2017 (Devoir de Vigilance Loi), in the Netherlands, the Dutch Child Labour Due Diligence Act 2019, in Germany, the German Corporate Due Diligence in Supply Chains Act 2021 and in Norway, the Norwegian Transparency Act 2021 (McCorquodale & Nolan, 2021; Johnstone & Hesketh, 2022), and at the European Union level the European Commission's Corporate Social Responsibility Due Diligence Directive (European Commission, 2022b). These mandatory human rights and environmental due diligence legislations establish a legal obligation on corporate businesses to identify, prevent, mitigate, and account for human rights and environmental harms in their operations and supply chains. To enforce corporate accountability for the embodied human exploitation and adverse environmental impacts in their business, these reporting requirements focus on operations and supply chains (Nelson, Martin-Ortega, & Flint, 2020). Apart from having reporting requirements, these laws impose obligations on corporate businesses, such as performing human rights due diligence and the imposition of penalties if these obligations are not met (Nelson, Martin-Ortega, & Flint, 2020; Johnstone & Hesketh, 2022).

2.3.2 Description of the policy

On June 1, 2023, the European parliament voted in favor of the Corporate Sustainability Due Diligence Directive which was proposed by the European Commission on February 23, 2022. The EC directive 2022/0051 imposes mandatory human rights and environmental due diligence requirements on businesses to promote sustainable and responsible business behavior throughout global value chains (GVCs). This obligation to exercise due diligence applies to EU limited liability firms that exceed a particular threshold in terms of their size and volume of operations, to other EU limited liability companies working in certain high-impact areas (including textiles, agriculture, food, metals and mineral extraction), as well as to similarly situated non-EU businesses

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operating in the EU. The scope of the EC directive 2022/0051 does not directly apply to small and medium-sized businesses (SMEs). However, it is anticipated that the cascading effect and spillover of the due diligence responsibilities of multinational corporations will have an indirect impact on SMEs (European Commission, 2022b; Methven O'brien & Martin-Ortega, 2022).

Specifically, the companies and sectors subject to the new due diligence law are:

1. All EU limited liability companies with 500 or more employees and make above EUR 150 million in net turnover globally;
2. Other EU limited liability companies operating in defined high-impact sectors, which do not meet both thresholds above, but have more than 250 employees and a net turnover of EUR 40 million or more globally. These companies will be subject to the new rules 2 years later than the companies included above;
3. Non-EU companies operating in the EU with a turnover threshold that is comparable to companies in Groups 1 and 2 and generated in the EU (European Commission, 2022b).

EU Member States must ensure that companies subject to the EC directive 2022/0051: (i) conduct and integrate human rights and environmental due diligence into their corporate policies; (ii) identify actual or potential adverse human rights and environmental impacts; (iii) prevent or mitigate potential impacts; (iv) bring to an end or minimize actual impacts; (v) establish and maintain a complaints procedure; (vi) monitor the effectiveness of the due diligence policy and measures; and (vii) publicly communicate on due diligence (Articles. 4-8). The EC directive's due diligence obligation covers not just a company's internal operations that fall within its purview, but also its subsidiaries and "value chain operations" to the extent of its "established business relationships" (Article 1) (European Commission, 2022b).

Regarding the environmental scope of the EC directive 2022/0051, Article 6 stipulates that "adverse environmental impacts" must be covered as part of the due diligence process, and Article 3 defines this term as "an adverse impact on the environment resulting from the violation of one of the prohibitions and obligations pursuant to the international environmental conventions listed in the Annex, Part II." The Annex includes reference to the following conventions: the Convention on Biological Diversity (CBD); the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); The Minamata Convention on Mercury; The Persistent Organic Pollutant (POPs) Convention; The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade; The Vienna Convention for the Protection of the Ozone Layer; and The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. In addition, the Large EU limited liability companies covered by the directive are also obligated to establish a climate change strategy that is compatible with limiting global

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warming to 1.5 °C in line with the Paris Agreement (Article 15) (European Commission, 2022b).
The EC directive 2022/0051 outlines monitoring (Art. 10), reporting (Art. 11), and enforcement procedures for corporate obligations related to human rights and the environment. These procedures include company-level complaint procedures (Art. 9), actions taken by national supervisory authorities (Art. 16–21), and civil liability for damages to human rights and/or the environment resulting from due diligence failures (Art. 22). (European Commission, 2022b; Methven O'brien & Martin-Ortega, 2022). In addition, the Large EU limited liability companies covered by the directive are also obligated to establish a climate change strategy that is compatible with limiting global warming to 1.5 °C in line with the Paris Agreement (Article 15).

2.3.3 Mechanism of the instrument for internalization

Due diligence is a standard procedure in business that enables organizations to fulfil legal responsibilities, or more practically assists companies in identifying significant business risks. Due diligence is now a mechanism to address the salient impact of corporate activities on people and the environment rather than a process to identify material risks for the company (Nelson, Martin-Ortega, & Flint, 2020). This mechanism has been adopted in the EC directive 2019/1937 known as the Corporate Social Responsibility Due Diligence Directive specifically to protect the environment and address human rights issues in global and national supply chains. For EU limited liability companies in the scope, due diligence in relation to human rights and the environment entails a procedure to identify, assess, prevent, mitigate, monitor, report, and remedy adverse effects on human rights and the environment in the supply chain, as well as embedding ethical business practices into corporate policies and management systems (European Commission, 2022b).
For the non-EU limited liability companies in scope, the EC directive can serve as a market-based, demand-driven standard. As the EC directive gets transferred into the law of all member states, EU limited liability companies in the scope will have a legal obligation to identify, prevent, mitigate, and account for human rights and environmental harms in their operations and their value chains. On the other hand, third (developing) countries and non-EU companies in scope can comply with the human rights and environmental standards set by the EC directive to access higher-value markets in the EU and improve their export performance. Policy makers use several similar demand-driven sustainability initiatives, including environmental and social certifications, product labels, responsible sourcing and monitoring plus verification systems, to promote and enable responsible and sustainable business practices, products, supply chains and investments (OECD, 2022).
The EC directive does not directly alter the costs or prices of food products to secure or assist the internalization of externalities along the food value chains. However, companies affected by the EC directive will incur additional company-level costs

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resulting from preparatory measures required to comply with the regulations as well as recurrent costs relating to audits, data collection to verify suppliers are providing credible information and filling necessary forms (Smith et al., 2020). The cost of complying with such due diligence legislations can be high, particularly in the case of long and complex supply chains. Companies may pass these costs to consumers as they raise the prices of their products to finance the additional cost of compliance (Kolev & Neligan, 2022).

2.3.4 Policy impacts

The theory of change that Nelson, Martin-Ortega, & Flint (2020) developed for human rights due diligence frameworks can be adopted to unpack how the directive can create change, influence the targeted actors or institutions and achieve the desired impact on human rights and the environment. The theory of change as a whole predicts that the new due diligence laws will influence companies and supplier practices and eventually make a positive impact on workers, producers, communities, and environments. The binding requirements and expectations that the directive sets may lead to changes in companies' policies, their management systems, and operations. Companies that are subject to the new law would therefore need to consider the risks that their operations and business relationships pose to the human rights of people involved in their supply chain, as well as take steps to prevent and reduce such risks and offer remedies when violations do occur. The companies would need to uphold the elements of the human rights policies outlined in the directive, including developing an appropriate human rights policy, conducting due diligence, and establishing processes to allow for the remediation of any negative effects on human rights that the company may cause or contribute to. In response to the new law, companies are also expected to alter their policies and procedures in their operations and commercial relationships with suppliers, subcontractors, and subsidiaries. As a result, suppliers' policies and practices such as those pertaining to working conditions and labor rights would alter. Finally, all of these changes would in turn positively impact the human rights of the people within the supply chain and potentially bring a broader societal shift with respect to human rights. The theory of change is drawn by making assumptions at each level, relating to the design of legislations, their implementation and the contextual factors that influence human rights protection, that must hold true for the intended effects to materialize (Nelson, Martin-Ortega, & Flint, 2020). Figure 7 below depicts the theory of change that is adopted from Nelson, Martin-Ortega, & Flint, 2020 to highlight the mechanisms inherent to the directive that have the potential to prevent harm to human rights and the environment.

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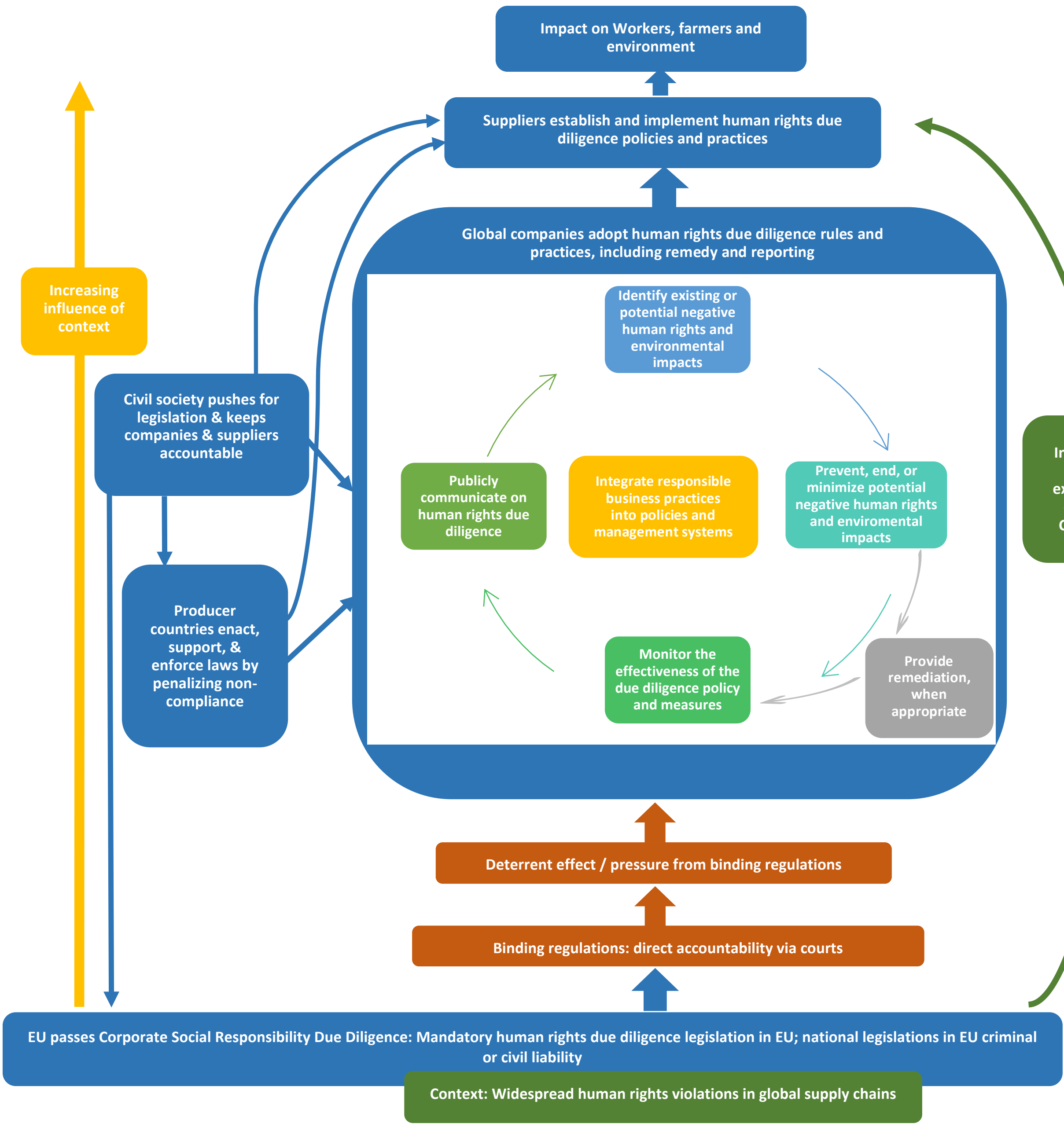
Figure 7: Theory of change for EU's corporate sustainability due diligence for human rights



Source: Adopted from Nelson, Martin-Ortega, & Flint (2020).

However, the relative novelty of due diligence laws, the paucity of evidence supporting the theory of change provided above, and other factors influencing corporate behavior provide some fundamental difficulties in evaluating the impact of the EC directive. Since

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laws requiring corporations to exercise due diligence in protecting human rights and the environment are still relatively recent, their reactions are also developing (Nelson, Martin-Ortega, & Flint, 2020). The majority of the impact evaluation of such laws pay very little attention to, or have no way of verifying, what is actually happening on the ground and instead rely on publicly available company records and statements. Most of the impact studies also rather focus on how company policies and procedures have changed rather than the effects on the supply chain or even specific effects on human rights (Nelson, Martin-Ortega, & Flint, 2020; Smith et al., 2020). Importantly, much of the current analysis concentrates on regulatory designs and how well they can be implemented, as well as responses from businesses and suppliers, rather than considering or measuring any potential effects on human rights and the environment, or even providing any empirical evidence of the impacts on the ground (Nelson, Martin-Ortega, & Flint, 2020; Smith et al., 2020).

Notwithstanding these limitations, this section provides preliminary insights into the potential impact of the EC directive on human rights and the environment in third (developing) countries based on the EC impact assessment of the directive and other existing impact evaluations of related laws, research, publications, and scholarly literature. The EC directive requires companies to include their GVCs in their due diligence procedures as well as immediately apply to some non-EU businesses. Therefore, the EC directive has a significant external dimension and will unavoidably have an impact on businesses and other stakeholders in third (developing) countries. It may also have a wider impact on the economies of third (developing) countries as the most significant negative effects on human rights and the environment frequently occur outside the EU (European Commission, 2022c). Hence, the impact assessment in this section will focus on the external impact of the EC directive.

2.3.4.1 Impact on final quantity produced and consumption

The EC directive is anticipated to increase the cost of companies per their direct and indirect supplier relationships, as the companies are required to audit each of their business relationships in their value chain for compliance with human rights and environmental standards (European Commission, 2022b). Companies also face risks for each supplier that human rights abuses would initially go unnoticed before being punished with fines or expulsion from public contracts (Felbermayr et al., 2021). These implicit costs and risks may affect how companies behave. To minimize the implicit costs and risks, companies in the scope of the EC directive might reduce the number of suppliers they use, move parts of their supply chains to industrialized nations where the danger of human rights breaches is absent, is smaller, or is simpler to monitor, or completely relocate the value creation back to their own company (Felbermayr et al., 2021; Smith et al., 2020). Recent evidence is showing that to be the case. Using a recent survey by the German Economic Institute (IW) on the potential effects of the German Act on Due Diligence in Supply Chains, Kolev and Neligan (2022) found that about 12

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percent of companies intended to leave countries with poor governance structures (mainly developing and emerging countries), and over 18 percent intend to only purchase upstream products from countries that uphold high standards for environmental protection and respect for human rights. Kolev and Neligan (2021) found a decrease in the value of trade with nations with lower per capita income levels and former French colonies after the adoption of the corporate due diligence statute in France. The rate of withdrawal is likely to be high for non-EU countries with a reputation for having significantly high human rights and environmental risks (Smith et al., 2020). The disengagement effect could however be advantageous for the EU Single Market's value-added (production) and employment creation in the long term. The relocation of investment to the EU and/or the sourcing of inputs from suppliers based in the EU could result in higher levels of production and employment, respectively, in addition to the direct employment effects brought on by businesses' need to adhere to the new law (Smith et al., 2020).

The EC directive will also increase the cost of suppliers concerned if they want to comply with their documentation obligations. These costs can be treated as trade costs since they only arise when exporting (after all, there is no need for additional documentation for the local market) (Felbermayr et al., 2021). The existing evidence indicates that such an increase in trade costs decreases the amount of exports made by the affected firms and even compels the least productive exporters to withdraw from GVCs (Melitz and Ottaviano, 2008). The decline in export can in turn lead to lower productivity of firms and lower economic activity in the third (developing) countries. If suppliers from developing countries leave global supply chains, the progress of developing countries catching up economically to industrialized countries runs the risk of being slowed down or even stopped (Felbermayr et al., 2021). All of these will have a consequence for the production and consumption patterns of third (developing) countries.

2.3.4.2 Impacts on externalities

2.3.4.2.1 Impacts on environmental externalities

Mandatory due diligence standards would obligate EU businesses to identify and stop any environmentally harmful activities connected to their international operations and those run by suppliers in third (developing) countries. Therefore, the EC's study on due diligence requirements through the supply chain argues that the mandatory due diligence requirements from EU companies might facilitate the implementation of tighter environmental legislation in third (developing) countries, supporting the establishment of a level playing field in the third country of the supply chain company. Stronger environmental due diligence among EU companies may have spillover effects even if stricter legislation is not passed in third (developing) countries. EU companies will ideally be sourcing from suppliers that uphold their environmental obligations, and as a result, companies in third (developing) countries may voluntarily increase compliance with environmental regulations outside of their jurisdiction due to simple competitiveness (Smith et al., 2020). Overall, EC directive's effects on combating climate

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change, biodiversity loss, promoting resource use efficiency, maintaining the quality of natural resources and preventing pollution, protecting and restoring biodiversity, ecosystems and their functions, reducing and managing waste, and halting deforestation would all be positive (Smith et al., 2020). Apart from the EC's study on due diligence requirements through the supply chain, none of the studies identified through the systematic review examine environmental externalities.

2.3.4.2.2 Impacts on social and health externalities

According to the EC's study on due diligence requirements through the supply chain, "the most salient adverse impacts on human rights and the environment occur primarily outside the EU". Therefore, the key trading partners of the EU and nations with generally lower sustainability requirements are among the third (developing) countries that are anticipated to be most affected by this initiative. Based on the available evidence, the EC study anticipates some positive effects, including enhanced labor and human rights, increased stakeholder awareness and adoption of international standards, improved access to remedies for abuse victims, and economic benefit for regional communities (Smith et al., 2020). On the whole, favorable effects are anticipated in terms of job quality, wages, working conditions, the elimination of child labor in the supply chains, and the respect for the human rights of vulnerable stakeholders impacted by company operations (Smith et al., 2020).

On the other hand, the EC study highlights that the new law could have a negative impact if the affected EU companies withdraw from third (developing) countries. This might negatively affect employment in third (developing) countries, or it might encourage other companies from countries with fewer restrictions or no regulations at all to enter these markets, which would result in a negative effect on the workers and working conditions in these nations (Smith et al., 2020). Applying the findings from the study of German businesses to the EU level, Kolev and Neligan (2022) conclude that the implementation of a due diligence law can have a catastrophic effect on emerging markets. They estimate that approximately every tenth job produced by EU corporations in third (developing) countries could be at risk if 12 percent of the companies stop operating in those nations with poor governance. Additionally, they found that as a result of the German Supply Chains Act's introduction, nearly one in five businesses intend to exclusively buy intermediate items from nations with strong standards for human and labor rights as well as the environment. The survey's findings of Kolev and Neligan (2022) concur with those of an empirical analysis by Kolev and Neligan (2021), who used data on French trade to analyze the effects of the Loi de Vigilance, a French law requiring due diligence, on trade. After accounting for the evolution of the standard gravity factors, the findings show that the implementation of the corporate due diligence requirement in France is linked to a consistently lower value of trade. Trade with France has decreased since the law's implementation, particularly with previous French colonies and those with lower per capita income levels. While this may drive some governments to put more effort into raising their nation's

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manufacturing standards, the general state of labor and human rights as well as environmental protection might remain the same or even deteriorate in some nations (Kolev & Neligan, 2022). Additionally, Nelson, Martin-Ortega, & Flint (2020) argue that, given the fact that suppliers are already squeezed by low pricing, if mandatory human rights due diligence laws lead to increased costs for suppliers, but not to increased prices to cover those costs, there is a risk that workers and farmers will be further disadvantaged as the cost are passed down to the weakest suppliers and vulnerable groups within the supply chain. Small suppliers and small farmers are least able to meet the costs of compliance. Generally, mandatory human rights due diligence laws may force difficult trade-offs between employment and human rights unless the appropriate safeguards are built into due diligence laws with regard to the impacts on weakest suppliers and vulnerable groups (Nelson, Martin-Ortega, & Flint, 2020).

2.3.4.2.3 Impacts on economic externalities

Mandatory due diligence laws such as those proposed in the EC directive have the capacity to establish and standardize legislation, to introduce new, safe, and environmentally friendly technologies into third (developing) countries, and even to promote innovation in production procedures. Companies in developing countries can take advantage of the due diligence efforts or certifications of their buyers as a chance to improve their own procedures (Wuttke et al., 2022). However, as Felbermayr et al (2021) claim, such mandatory human rights due diligence laws may have mixed effects in that some suppliers may not be able to meet the new standards and requirements and may leave GVCs, but the suppliers that do remain will probably have better working conditions for their employees. Even if mandatory due diligence laws have favourable impacts for companies that participate in GVCs, such as economic and social upgrading, this does not imply benefits to be there for the industry as a whole or for the particular country (Ponte, 2019). As was observed for the South African wine industry, significant economic and environmental improvement procedures may not produce favourable economic results for the majority of local participants and the likelihood of significant environmental outcomes might be low (Ponte, 2019; Wuttke et al., 2022).

From an economic standpoint, market regulations are frequently cited as a barrier to market entry and as an external factor reducing enterprises' competitiveness because of the administrative costs associated with compliance requirements (Smith et al., 2020). One could therefore categorize the mandatory human right due diligence laws as a so-called non-tariff trade barrier (Felbermayr et al., 2021). These are legislative measures that, at times, severely impede trade by implicitly raising trade costs (Ghodsi et al., 2017; Kinzius et al., 2019). Different standards that compel businesses to modify their products based on the particular norm of the target country are a common example of non-tariff trade barriers. A due diligence regulation, which mandates importers to investigate and document any human rights breaches at their suppliers, has an impact on trade costs as well and is therefore a non-tariff trade tool (Felbermayr et al., 2021). For developing nations, the EC directive may therefore be seen as a non-

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tariff trade barrier. Additionally, lead companies in GVCs frequently use sustainability as a means of product differentiation and marketing, shifting the responsibility to suppliers who must adhere to additional certifications, standards, audits, and traceability requirements without being compensated with higher prices (Ponte, 2019). Therefore, developing countries might face a risk of governance overload in the context of extra certification and standards, which could result in scenarios where private standards and private certifiers seize control and undermine local regulatory institutions (Wuttke et al., 2022).

Finally, the leakage or deviation impacts of mandatory human rights due diligence laws—buyers simply avoiding sourcing from developing countries with potential compliance challenges—are what are considered to be the most harmful effects of mandatory human right due diligence laws. Felbermayr et al. (2021) argue that if the EC directive leads the EU companies to avoid sourcing from third (developing) countries, this will inevitably result in decreased sales for impacted exporters in those countries. In turn, this decline in sales would result in business-related job losses, and in the worst scenario, the impacted enterprises completely withdraw from the market. This can then have an effect on the entire region(s), depending on the size of the affected companies. Former employees will be either forced into unregulated, informal labor marketplaces or go unemployed (Felbermayr et al., 2021). Small or informal businesses, as well as smallholders, would become "uncertified" in such circumstances and be abandoned. They would simply be ignored by buyers, and therefore they would no longer be covered by mandatory human right due diligence laws (Wuttke et al., 2022). Additionally, the mandatory human rights due diligence laws impact precisely those companies that already pay relatively high wages (Felbermayr et al., 2021), as evidenced by the fact that exporting enterprises pay greater wages on average than those that primarily serve the domestic market (Bernard et al., 2007). If the impacted companies continue to operate in the domestic market, they will no longer feel constrained by the labor laws they had established for their clients in the EU member states (Felbermayr et al., 2021).

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3 HEALTH SPHERE

Food Safety

[to be added to the policy by other FoodCost partner]

3.1 Food safety standards on imported agri-food products

3.1.1 Introduction

In many high-income countries, the concern and subsequent public discourse about necessary and appropriate food safety and quality standards have intensified. This led to tightening sanitary and phytosanitary standards in these countries beyond international standards (Otsuki et al. 2001). Sanitary and phytosanitary regulations, such as maximum residue levels (MRL) of pesticides, veterinary drugs, and food additives, do apply to all products traded and potentially consumed in the EU, including agri-food imports to the EU.

As described above in the section on EU standards on pesticides, fertilizer, etc, sanitary and python-sanitary (SPS) standards and regulations, next to internalizing health externalities, facilitate food production and exchange by addressing the information asymmetry problem in food markets related to unobservable quality characteristics of these products (Beghin et al., 2015). On the other hand, compliance with SPS and proofing that products comply with the standards causes an administrative burden on trading firms. This is of particular relevance for agri-food exporters who may face varying food standards at different export destinations. The World Trade Organization (WTO), in its Agreement on Sanitary and Phytosanitary Standards, has proposed to harmonize international SPS standards which are recorded in the joint FAO/WHO Codex Alimentarius Commission (Codex) for food safety. However, the agreement allows importers, such as the EU, to impose regulations stricter than the Codex standard and ban imports as an emergency measure when food safety cannot be guaranteed (Kareem et al., 2018)

The implementation of food safety standards is not free of cost for domestic producers as Santeramo and Lamonaca (2019) discuss, but the implementation costs of these measures may be higher in exporting countries, especially in LMICs with limited institutional capacity (Kornher et al. 2023). In this way, SPS standards deliberately or unintentionally act like other non-tariff measures (NTMs), such as technical barriers to trade, which can impede international trade. In agri-food trade, SPS standards represent the vast majority of NTMs. While import tariffs in agriculture were steadily reduced over the past decades, the number and complexity of technical and regulatory trade barriers have increased (Bueno Rezende de Castro and Kornher, 2023). Figure 8 presents the ad

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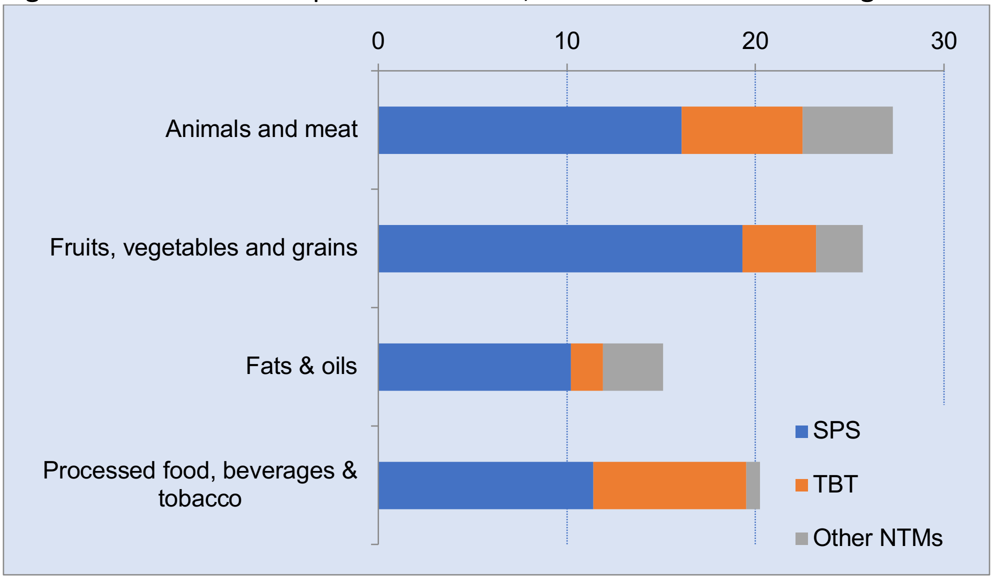
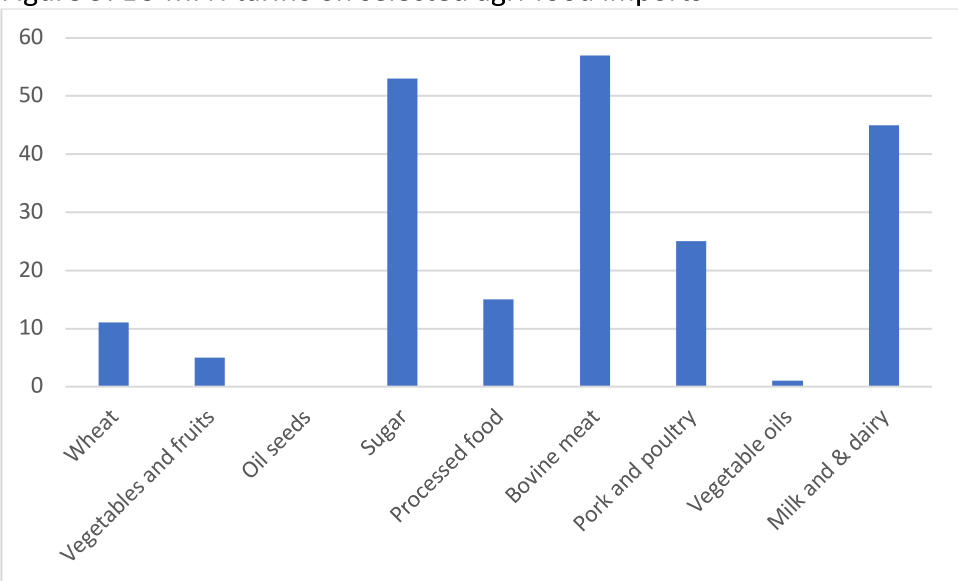
valorem equivalent of different NTMs for several agri-food sectors. This contrasts with relatively low import tariffs to the EU market (Figure 9) for several products, such as F&V, grains and oilseeds, and processed foods; besides the preferential market access for many LMICs under preferential trade agreements.

Figure 8 : Ad valorem equivalents of SPS, TBT and other NTMs in agri-food



Source: Adapted from Cadot et al. (2015). Note : SPS is sanitary and phyto-sanitary, TBT is technical barriers to trade, NTM is non-tariff measures.

Figure 9: EU MFN tariffs on selected agri-food imports



Source: Matthews (2018).

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3.1.2 Description of the policy

EU food safety regulations are based on the EU Regulation (EC) No 178/2002 known as the General Food Law and its amendments and replacements.[7] This regulation establishes the grounds for several EU regulations that address food safety issues. For instance, EC 1881/2006 on the MRL of certain contaminants in foodstuffs, including maximum levels for the metals lead, cadmium and mercury, EC 1370/2022 on MRL of ochratoxin A, or EC 396/2005 harmonizing MRL of pesticides.

The General Food Law also describes the import conditions from third countries by stating that only safe food and feed are allowed in the Union's market for human or animal consumption. On the legal basis of these regulations, importers to the EU market need to meet all food safety standards that also apply to EU producers. These standards are product specific. In addition to that, EU trade agreements provision that agri-food exporters need to certify sanitary and phytosanitary standards of their export produce, besides requiring an export license. Buyers in the EU may also demand additional quality standards, foremost GLOBALG.A.P.. The licensing and certification processes are often associated with significant transaction costs in LMICs, particularly if they cannot be done electronically (Bueno Rezende de Castro and Kornher, 2023).

The EC 1793/2019 establishes the Rapid Alert System for Food and Feed (RASFF) ensuring the exchange between member countries about food import's EU food safety standard violations, e.g. EU MRL. The RASFF improves the monitoring of food imports from countries and identifies countries with a high risk of food safety standard violations. It also allows to eventually impose import bans on the specific exporting country.

3.1.3 Mechanism of the instrument for internalization

The mechanism of the SPS is complex. This is because food standards have an effect on both the supply and the demand. In Figure 10, we illustrate the impact of a small food-producing and exporting country. For simplicity, we assume that the entire production is exported. The supply initial supply is given by S. The implementation of SPS measures in the importing countries creates implementation costs and shifts the supply upwards to S'. On the other hand, as agri-food products are credence goods, the introduction of SPS measures boosts the demand as the willingness to pay rises, and therefore, import demand (D) shifts to the right (Beghin and et al. 2015; Swinnen, 2016).

7 See EU Commission (accessed May 2023) https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32002R0178

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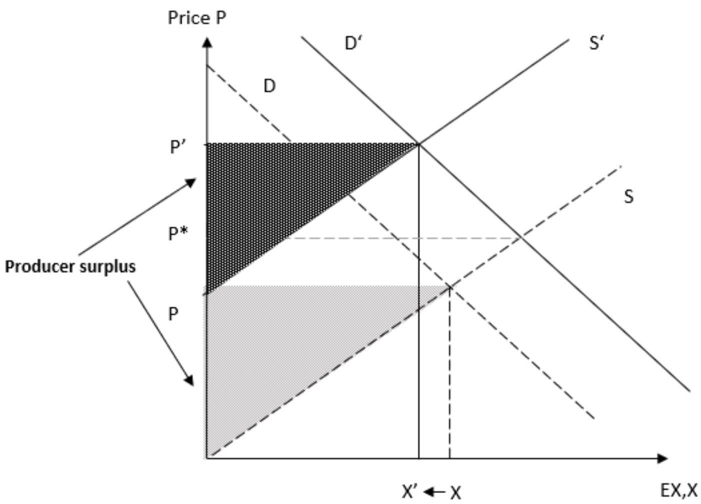
The new equilibrium price is above the initial price. The respective shifts in demand and supply, as well as elasticities of demand and supply, determine if the new export/import quantity is below or above the initial export quantity (in our case the export quantity declined). The intuition is the following: consumers gain due to the positive utility gain of the food safety standard that reduces information asymmetry, but they lose with an increasing price; producers gain from the increase in the price but lose due to the implementation costs of the standard. In the present case, the producer surplus decreases. In this case, the SPS acts as a barrier to trade. In fact, Swinnen (2016) shows that the effect can be determined from the magnitude of the price effects. If the price increase due to the demand growth (P*-P) is smaller (larger) than the price increase due to the cost increase (P'-P*), then the overall effect on welfare is negative (positive).

Figure 10: Effect of the SPS on export supply and import demand



Source: Adapted from Swinnen (2016).

Santeramo and Lamonaca (2019) describe the different scenarios and show how the SPS can also have a catalyst effect on export and producer welfare in the exporting country. They also show that the implementation of the SPS can also change the competitiveness of domestic and foreign supply, i.e. the substitutability between importers and exporters, and affect the slope of the supply function. As a consequence, the overall effect on exports and producer surplus becomes even less clear. These results gave rise to the use of the term NTM instead of a non-tariff barrier to illustrate the ambiguity of the SPS impact (Grant & Arita, 2017).

3.1.4 Policy impacts

3.1.4.1 Impact on final quantity produced and consumption

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Due to the focus of this secton on external and trade effects of EU food safety standards, we did not review studies with respect to the policies' impact on EU production and consumption.

3.1.4.2 Impacts on externalities

3.1.4.2.1 Impacts on environmental externalities

The studies identified through the systematic review did not examine environmental externalities.

3.1.4.2.2 Impacts on social and health externalities on non-EU countries

The discussion of the mechanism of the instrument on the producer surplus in the exporting country shows ambiguity. Therefore, the empirical evaluation is crucial. The effects are expected to vary across exporting countries and products, as the implementation costs and the demand growth effect will be product and country-specific.

The most comprehensive study on the topic is Santeramo and Lamonaca (2019a). They employ a meta-analysis based on a systematic review of the literature on the topic. The results show that MRLs tend to increase trade, but SPS and technical barriers to trade may not always reduce trade. Generally, the heterogeneity in results across trading partners and products is substantial, while a sound econometric approach improves the accuracy of the results. In a related paper, Santeramo and Lamonaca (2019b) specifically look at African agri-food exporters and show that the literature mostly finds that NTMs act as a barrier to trade for African exporters. This is similar to an earlier study by LI and Beghin (2012) who identify that NTMs are more likely to impede exports when the good is traded from a developing exporter to a developed country importer, which reduce income in the developing country. This is caused by larger compliance costs that benefit domestic producers over exporters. This is, on average, the case for both MRLs and SPS. Crivelli and Groeschl (2015) examine the importance of SPS regulations on both the intensive and extensive margin using data from 1995 to 2010. They find that SPS measures have a negative effect on the probability to export, but they could stimulate trade conditional on established market entry. However, all studies do not focus on the EU as the only importing country.

Kareem et al. (2018) examine specifically the effects of the EU's MRL for tomatoes, oranges, limes, and lemons using a standard gravity model. Since EU tomato requirements are stricter than the international Codex standard, while this is not the case for oranges and limes, and lemons, they display protectionist tendencies. However,

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when it comes to firms' decisions to export, oranges, limes, and lemons show anti-protectionist tendencies. This suggests that EU MRL regulations may only be intended to address legitimate concerns for human health and safety and may not necessarily address protectionist concerns. In another term, the benefits of solving the information asymmetry may be larger than the implementation costs. On the other hand, tomatoes represent a somewhat less import-dependent sector that is overprotected.

Several studies focus on the specific impact on F&V products that are subject to a wider range of SPS standards. Melo et al. (2014) find a significant negative effect of SPS on Chilean fruit exports to developed countries using data from 2005 to 2009. Dou et al. (2013) examine the impact of MRL on Chines F&V exports between 1996 and 2010. They show that Chines exports were decreasing in the number of regulated pesticides, the strictness, and the importing country's level of food safety standards. Another empirical paper employing the gravity model analyzes rice exports in Vietnam. Thuong (2018) shows that SPS measures were associated with significantly lower rice trade between Vietnam and the respective trade partner between 2000 and 2015. Interestingly, the author finds that the effect decreased the importing country's GDP.

A number of studies have also investigated the role of NTMs in the aquatic sector. Many of the regulations have become relevant due to the growing importance of aquaculture trade, which is – as opposed to wild fishing – a production system with controlled conditions including feed and chemical and microbiological contamination. Overall, the interconnectedness between food safety and animal health has posed specific challenges to the sector represented by specific regulations in the EU and other exporting countries (Bagumire et al. 2013). Szczepanski (2010) used a gravity model to test the effect of MRL on shrimps and prawns that are typically traded from developing to high-income countries with stricter food safety standards. Panel econometric results show that between 1995-2007, stricter MRL standards were significantly limiting trade in shrimp and prawns. Simulating the MRL harmonization suggested by the Codex, the authors estimate that the standards cost about US$1.5 billion in trade annually. This may be different for the fishery trade originating from wild fishing (Neeliah et al. 2014; Kareem and Martinez-Zarzosa, 2018)

A publishing bias could also exist; for example, case studies might be chosen because the country and the product raised doubts about the potential consequences of NTMs on exports. Besides, these studies cannot possibly cover all different food safety standards and MRL regulations. An interesting exemption is Drogue and DeMaria (2012) who use a similarity index for MRL between exporting and importing countries considering all pesticides listed. The gravity model shows, that for the EU, similarity has significantly increased apple and pear trade between 2000 and 2009.

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In conclusion, food safety standards can have both positive and negative external effects. For instance, harmonized food safety regulations, such as common MRL standards, could have positive effects on agri-food trade. However, in general, the literature mostly reports trade impeding effects of NTMs, in particular for African exporters. This is related to the weak institutional capacity of African exporters, which results in higher compliance costs (Kareem et al. 2022; Kornher et al. 2023).

In this review, we have neglected the indirect health effects of SPS implementation through food safety improvements in the exporting country. This is of particular relevance for Africa where food-borne illnesses due to microbial and chemical contamination remain the major public health risk (Aworh 2021). Food safety risks may be indeed highest among traditional export products, such as F&V products. These effects should be considered in future analysis.

3.1.4.2.3 Impacts on economic externalities

Compliance costs increase the transaction costs of exports. The studies identified through the systematic review did not examine economic externalities directly. However, the results on the impacts on social externalities suggest that impacts on transaction costs are substantial.

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Task 2.1 Individual report

Evaluating the role of EU food policies in internalising environmental and social externalities: A literature review

Deliverable type	Month and date of delivery
Report	May 2023

Work package	Leader
WP2	INRAe

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Internal	Courtois Anne-Maud, Borniotto Diana, Baret Philippe

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Horizon Europe	101060481	48 Months	June 2022

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1 THE ENVIRONMENTAL SPHERE

Responsibility for environmental policy making in Europe has extensively shifted to the EU level, with a growing number of measures aimed mostly at levelling the playing field between member states and achieving the harmonization of national policies (Knill and Lenschow 2005). To achieve the objectives set in the European legislation, Member States are expected to implement corresponding adjustments and changes in their national institutional structures. As evidenced by Knill et Lenschow (2005), this process has however not led to the convergence of regulatory arrangements across European countries. The reason would lie within the distinctive pattern of governance across the EU leading to divergent domestic environmental policies. As a result, the national transpositions of EU prescriptions differ greatly across MSs and lead to very different outcomes.

Chemical safety and biosafety

1.1 Fertilizers

1.1.1 Introduction

While the use of fertilizers has led to significant increases in crop yields, it has parallelly resulted in the emergence of severe negative externalities (Hasler et al. 2016; OECD Environment Directorate 2020). The production and use of synthesized nitrogen (N) fertilizers, in particular, are pointed out as major sources of environmental pollution, though other forms of fertilizers, including organic, can also result in negative externalities.

Among the environmental impacts of the use of fertilizers stems the emission of greenhouse gases during the production process, as well as during and after field application. Overall, the nitrogen fertilizer supply chain is responsible for an estimated 10.6% of agricultural emissions and 2.1% of global anthropogenic GHG emissions (Menegat, Ledo, and Tirado 2022). At farm level, nearly half of the N fertilizer supplied is not used by crops and is lost to the ecosystem through volatilization, run-off, or leaching (Martínez-Dalmau, Berbel, and Ordóñez-Fernández 2021). In addition to their contribution to the release of greenhouse gases, these losses lead to additional environmental degradations. These include direct toxicity to organisms and indirect impacts through factors such as nutrient enrichment, oxygen depletion in aquatic ecosystems, soil or water acidification or intensifying the impact of other stressors such as pathogens, invasive species and climate change (OECD Environment Directorate 2020; Martínez-Dalmau, Berbel, and Ordóñez-Fernández 2021). Negative environmental externalities linked the use and production of fertilizers further include the depletion of non-renewable resources, such as phosphorus and potassium (Hasler et al. 2016).

Fertilizers can contain substances that may potentially pose a risk for human and animal health. Long-term use of chemical fertilizers and organic manures has been showed to contribute to the accumulation of heavy metals in agricultural soils (Atafar et al. 2010; Focker et al. 2022). Among these, Cadmium (Cd), a highly toxic contaminant, is of most concern. Other heavy metal associated with the use of fertilizers include chromium (Cr), copper (Cu), and zinc (Zn). By increasing the concentrations of these heavy metal in agricultural soils and derived crops and products, fertilizers pose a risk of food contamination (EFSA 2009). In addition to the potential presence of chemical hazards, microbiological hazards may also be present in the form of pathogenic bacteria present in animal manure (Focker et al. 2022). Finally, pharmaceuticals, among which antimicrobials, are another major concern in animal manure, leading to resistance issues (Focker et al. 2022).

1.1.2 Description of fertilizer-related policies at EU-level

In order to manage the risks posed by the production and use of fertilizers to the environment and the health of humans and animals, the EU has developed a number of policies aimed at regulating practices and harmonizing standards across countries. Table 1 highlights the most prominent EU policies for fertilizers management in food systems, by chronological order.

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Table 1. List of main EU policies enabling the internalization of externalities linked to fertilizers in food systems

Policy ID	Title	Topic	Date of entry into force	Date of application	History
Council Directive 91/676/EEC	Concerning the protection of waters against pollution caused by nitrates from agricultural sources	Nitrate Directive	Dec 1991	Dec 1993	
Directive 2000/60/EC	Establishing a framework for Community action in the field of water policy	Water Framework Directive	Dec 2000	Dec 2003	
Directive 2006/118/EC	On the protection of groundwater against pollution and deterioration	Groundwater Directive	Jan 2007	Jan 2009	
Regulation (EU) 2019/1009	Laying down rules on the making available on the market of EU fertilizing products	Fertilizers marketing	July 2019	July 2022	Repealing Regulation (EC) 2003/2003; Amending Regulations (EC) 1069/2009 and (EC) 1107/2009

1.1.2.1 Council Directive 91/676/EEC – Nitrate Directive

Council Directive 91/676/EEC, known as the Nitrates Directive, was adopted by the EU in 1991 with the objective of reducing water pollution caused or induced by nitrates from agricultural sources. It includes measures aimed to prevent or reduce nitrate pollution from livestock manures and other fertilizers through the establishment of national Action Programmes, which include mandatory measures for vulnerable zones, and codes of Good Agricultural Practices, which consist mostly of voluntary-based measures to be implemented by farmers.

The implementation of the Nitrate Directive is one of the Statutory Management Requirements that farmers must comply with in order to receive direct payments under the CAP. In addition, the directive's requirements are also included as part of the cross-compliance measures that farmers must comply with in order to receive certain direct payments under the CAP. For an overview of the role and impact of the CAP on the internalization of food systems' externalities, see Section 3 THE ECONOMIC SPHERESupport to the agricultural sector.

1.1.2.2 Directive 2000/60/EC – Water Framework Directive

Directive 2000/60/EC establishes a framework for Community action in the field of water policy. It includes measures to prevent or reduce pollution from agriculture, including environmental quality standards for pesticides in surface water.

Related policies:

- Directive 2008/105/EC on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council
- Directive 2013/39/EU amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy

1.1.2.3 Directive 2006/118/EC – Groundwater Directive

Directive 2006/118/EC aims to protect groundwater against pollution and deterioration, including through measures to prevent or reduce contamination from fertilizers.

1.1.2.4 Regulation (EU) 2019/1009 – Fertilizers marketing

On July 2022, Regulation (EU) 2019/1009 entered into force with the main objectives of harmonizing the regulation of fertilizers among EU Member States and minimizing any present and future adverse health and environmental effects due to the use of fertilizers (Regulation (EU) 2019/1009 2019). This is the main piece of legislation directly targeting externalities associated with fertilizers.

This new fertilizer Regulation has extended the categories of fertilizers covered by EU regulations, from a focus on mineral fertilizers in the repealed Regulation (EC) 2003/2003 to the inclusion of recycled and organic materials. It also provides for a number of obligations for manufacturers, importers and distributors of fertilizers, mainly to limit the content of contaminants in products (in particular for Cadmium) and to introduce more extensive labelling requirements. The harmonization standards introduced by Regulation (EU) 2019/1009 are however optional, meaning that manufacturers and distributors of fertilizer products can choose whether to comply with the EU procedure or follow national regulations for placing their products on the market.

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By encouraging the supply of safe and high-quality fertilizer products coming from recycled domestic organic sources, this regulation is considered an important step towards Circular Economy (Marini, Caro, and Thomsen 2020).

1.1.3 Main policy instruments and mechanisms for the internalization of externalities

According to the literature review by Marini, Caro, et Thomsen (2020), besides the Common Agricultural Policy (CAP), the relevant legislations covering the impact of fertilizer consist essentially of command-and-control (C&C) instruments. This is in line with the view of Lally et van Rensburg (2007) stating that, while both economic (input taxes) and regulatory (input regulations and management practices) policy instruments can be used to deal with nitrate pollution, in practice command-and-control (regulatory) measures are mostly implemented. Four reasons are given by Lally et van Rensburg (2007) to explain that situation, with the example of nitrogen fertilization:

1. Imposing an input tax – on for instance nitrogen – would prove very difficult for the EU as the level of taxes required to achieve the objective in terms of organic and inorganic application rates would vary significantly across countries and even between producers within each country.
2. There is no direct link between an input tax and the level of nitrate emissions, which means that there is a high level of uncertainty regarding policy outcome.
3. The tax only targets the quantity of fertilizer purchased, not the field application.
4. A tax on nitrogen inputs would have little or no impact on other risk factors that may cause pollution of waters by nitrates, particularly the timing of application.

The following evaluation section mostly concentrates on regulatory instruments. A distinction is made between ex-ante risk assessment (conformity checks), market & post-market risk management (labels) and implementing tools, including the Good Agricultural Practices and Action Programmes established through the EU Nitrate Directive.

Table 2 lists these main instruments used in fertilizer regulations, with references to the group of actors primarily targeted by the instrument, its ultimate beneficiaries, and the type of externalities addressed. Since economic tax-based policy instruments are not currently mandated at EU-level, such instruments are not reviewed in the present paper. The evaluation section will nonetheless present a brief overview of academic position on this topic.

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Table 2. List of policy instruments used in the main EU policies regulating fertilizers in food systems

Instrument category	Instrument topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
					Socio	Envi
C&C Ex-ante risk assessment	Fertilizers' conformity	Regulation (EU)2019/1009	Agro-industry	Society at large	Food safety; Animal Welfare	Climate change; Acidification & eutrophication; Direct effects on biodiversity & ecosystems; Toxicity
C&C Market & post-market risk management	Labelling	Regulation (EU)2019/1009	Agro-industry	Farmers	Consumers' rights	
C&C Implementing tools	Agricultural Practices & Action Programmes	Directive 91/676/EEC	Farmers	Society at large	Food safety; Animal Welfare	Climate change; Acidification & eutrophication; Direct effects on biodiversity & ecosystems; Toxicity

1.1.3.1 Ex-ante risk assessment (Fertilizers' conformity) – IOE mechanism

By requiring an ex-ante assessment of fertilizing products before their marketing, Regulation (EU) 2019/1009 aims at harmonizing the EU fertilizer market and minimizing adverse health and environmental effects due to their use. This instrument is designed to reduce both social and environmental externalities by addressing various impacts caused by fertilizers, including food safety, animal health, climate change, acidification, eutrophication, direct effects on biodiversity and ecosystems, and toxicity. This instrument therefore aims to reduce the social and environmental externalities caused by the use of fertilizers by requiring industries (fertilizers' manufactures and retail) to release products that comply with strict standards, thus minimizing the subsequent impacts of fertilizers at farm-level.

1.1.3.2 Market & post-market risk management (Labelling) – IOE mechanism

Labelling is an instrument used in agri-food systems to provide accurate information to producers and consumers. By ensuring the availability and transparency of information, labelling allows for freedom of choice, as users can make informed decisions about the products they purchase based on their values and preferences.

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1.1.3.3 Implementing tool (Good Agricultural Practices and Action Programmes) – IOE mechanism

Good Agricultural Practices and Action Programmes are established in order to stimulate a change in the behavior of agricultural producers, encouraging practices that align with the objectives of the regulation, i.e. reducing water pollution caused or induced by nitrates from agricultural sources.

On the social side, GAPs and Action Programmes help to improve food safety and animal health by reducing the levels of contaminants from fertilizers in the food and feed chain.

On the environmental side, this instrument contributes to the reduction of multiple externalities, including climate change, acidification and eutrophication, direct effects on biodiversity and ecosystems, and toxicity. By reducing the amount of contaminants from fertilizers that enter water bodies, GAPs and Action Programmes help to prevent or mitigate the negative impacts of these externalities. Moreover, GAPs and Action Programmes can contribute to the improvement of farming practices and the adoption of more sustainable approaches in agriculture. This can lead to better use of resources, reduced environmental impacts, and increased resilience to environmental changes.

1.1.4 Evaluation of the impact of policy instruments on the internalization of externalities associated with fertilizers

Overall, the EU is recognized as one of the most active region in the area of soil protection, despite a yet lacking comprehensive and legally binding legislation scheme (Marini, Caro, and Thomsen 2020).

In their 2020 paper, Marini, Caro, et Thomsen present an overview of the limits pertaining to current legislations aimed at addressing the impact of fertilizers, in particular Regulation (EU) 2019/1009. Although command-and-control law is reported as a necessary instrument for the protection of agricultural soils, it is seen by the authors as inadequate to guarantee full soil protection in the EU. Given the limitations of current legislation, the authors stress the need for complementary policy instruments aimed at protecting and conserving agricultural soil health. In that sense, the recently proposed, and subsequently withdrawn, EU Soil Framework Directive (SFD) was considered a meaningful complementary policy tool. Member States rejected the SFD on the ground of subsidiarity principle, claiming that it would have interfered with the national soil policy and, since soil would not constitute a cross-border issue – unlike air and water – the EU would have no right to regulate it. The authors nonetheless question that reasoning, given the fact that externalities from soil health are embedded in the global food trade.

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1.1.4.1 Ex-ante risk assessment – Fertilizers' conformity

1.1.4.1.1 Environmental impacts

By assessing compliance with established limits for contaminants presence in fertilizers, the ex-ante procedure should allow for a reduction in **environmental pollution**. However, the instrument is judged ineffective in that sense.

Similarly to other soil protection legislations, the instruments used in Regulation (EU) 2019/1009 are accused of considering soil protection as a beneficial side effect, rather than a primary objective (Marini, Caro, and Thomsen 2020). These policies are considered to have a single objective: guaranteeing the highest agricultural land productivity while safeguarding human beings from contaminants. Therefore, by simply limiting the chemical threats for humans, the assessment of fertilizers fails to consider sustainability as a whole, including the restoration, support, and conservation of natural resources and ecosystem services (Marini, Caro, and Thomsen 2020). In doing so, the assessment of fertilizers, particularly manure-based, fails to appropriately consider soil **biodiversity** issues (Köninger et al. 2021).

To effectively integrate the reduction of negative externalities associated with the use of fertilizers, EU policies and conformity assessment would need to recenter their goals on the overall protection of the environment.

1.1.4.1.2 Economic impacts

Market-wise, since Regulation (EU) 2019/1009 has opened from 2022 onwards a market for manure and biostimulant products, while regulating more strictly mineral fertilizers, the access and value of organic fertilizers are likely to increase (Köninger et al. 2021). The established level-playing field should further ensure better access to the internal market to innovative companies. In this respect, the regulation is expected to impact the overall **structure of the EU market**. However, it should be noted that Regulation (EU) 2019/1009 is based on the principle of optional harmonization and will thus not overrule national legislations.

1.1.4.2 Market & post-market risk management – Labelling

1.1.4.2.1 Social impacts

Regulation (EU) 2019/1009 introduces labelling requirements that are much more extensive than the previous Regulation (EC) 2003/2003. This reflected new social demands and concerns, as well as the fact that the new rules drastically opened the EU market for products that are innovative and unknown, and therefore require better user information (European Commission 2023b). However, overloaded labels were reported to cause legibility problems for interested parties, as the provision of numerous details on a label makes it difficult to identify the essential information (European Commission 2023b). While labelling is essential to ensure the **availability of accurate and**

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transparent information to producers and consumers, the overloading of information might actually **hinder transparency** efforts.

1.1.4.2.2 Economic impacts

On an economic aspect, labels were reported to cause management difficulties for economic operators who need to cover the increasing **transaction costs** of adequate labelling (European Commission 2023b).

1.1.4.3 Implementing tool – Good Agricultural Practices & Action Programmes

As a foreword, Kanter et al. (2020) note that most policies dedicated to reducing agricultural pollution, particularly nitrogen, focus on changing farmer behavior. However, they stress that farm-level policies are challenging to implement, and that farmers are just one of several actors in the agri-food chain. The activities of other actors — from fertilizer manufacturers to wastewater treatment companies — are seen as equally important in reducing nitrogen losses at the farm level and beyond and thus need to be equally targeted (Kanter et al. 2020).

1.1.4.3.1 Environmental impacts

According to the Nitrate Directive, Member States are required to establish codes of Good Agricultural Practices (GAP) that should be implemented by farmers and specific Action Programs including mandatory measures for vulnerable zones.

Although GAP set by MSs are generally reported to have improved the use efficiency of fertilizers (Monteny 2001; Deneufbourg et al. 2013; De Vries et al. 2015; Buckley et al. 2016; Gomes, Antunes, and Leitão 2023; López-Ballesteros et al. 2023), the nitrogen surpluses did not necessarily decrease accordingly (Köninger et al. 2021; Ricci et al. 2022). Indeed, EU Member States reports concerning their national water bodies status reveal that the applied measures remain globally insufficient to reduce **groundwater contamination** (Gomes, Antunes, and Leitão 2023). In 2020, the European Commission had to urged France, Italy, Belgium and Spain to comply with nitrate thresholds for losses to water tables set in the Nitrates Directive (Köninger et al. 2021).

In Ireland, results from Buckley et al. (2016) suggest some positive impact of the GAP regulations on N management in dairy farms, with a potential double dividend effect of increased returns to agricultural production while reducing the risk of N transfer to the aquatic **environment** (undissociated impacts). However, while this improvement in nutrient management efficiency is in part likely due to application limits and other measures imposed under the GAP regulations, the authors recognize the influence of other factors, including fertilizer prices, stocking rates, contact with agricultural advisors, and climatic variables. It is therefore very difficult to directly attribute to the Good Agricultural Practices any impact observed at farm-level.

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Furthermore, impacts of agri-environmental practices such as those included in the Good Agricultural Practices & Action Programmes are likely to be highly context-dependent, with very different outcomes in the different European countries and regions (Baaken 2022; Ricci et al. 2022).

1.1.4.3.2 Economic impacts

By enhancing efficiency in fertilizers' use and best management practices, the Good Agricultural Practices & Action Programmes may generate savings for farmers in the form of reduced fertilizer expenditures and increased yields (Kanter et al. 2020). Furtheremore, Kanter et al. (2020) suggest that such an instrument may also increase revenue for the fertilizer companies that produce and provide fertilizers, given that many enhanced efficiency fertilizer and best management practices services are patent-protected and thus have a higher profit margin for those companies.

Besides these direct economic impacts, the implementation of Good Agricultural Practices and Action Programmes might induced positive **knowledge capital spillovers**. Indeed, through its call for a 50% reduction of nutirent loss in the Green Deal and its mandate to introduce Good Agricultural Practices & specific Action Programmes, the European Commission is stimulating new studies to investigate the recycling and nutrient recovery potentials of various fertilizers options, as well as additional measures and new technologies that can minimize the pressures on waters and soil (Köninger et al. 2021; Ricci et al. 2022). Furthermore, knowledge of on-farm fertilizing and manure treatment methods needs to be spread, e.g., through training and agricultural extension work.

1.1.4.4 Synthesis of EU fertilizer policies' impacts on social, environmental and economic factors

Table 3 provides a synthesis of the impacts of EU fertilizer policies and their instruments on social, environmental and economic externalities, as suggested by the literature review.

Table 3. Synthesis of reviewed positive (+), negative (-), and non-directional (/) impacts of EU fertilizers policy instruments on social, environmental and economic factors

	Social	Environmental	Economic
Ex-ante risk assessment	(+) (-) (/)	(+) (-) Biodiversity (/) Environmental pollution	(+) (-) (/) Market structure
Market & post-market risk management	(+) Transparency (-) Transparency (/)	(+) (-) (/)	(+) (-) Transaction costs (/)
Implementing tools	(+) (-) (/)	(+) Undissociated (-) (/) Water contamination	(+) Knowledge capital (-) (/)

1.1.4.5 Brief overview of tax-based instrument

Taxes can be used to internalize the external environmental (and health) costs of pesticides and fertilizers and have been adopted in a few countries (OECD Environment Directorate 2020).

In the EU, some European countries including Sweden, Norway, Finland and Austria, implemented the 1970s and 1980s taxes on mineral N fertilizer to address the pollution of water bodies (Meyer-Aurich et al. 2020). These tax policies were substituted by direct regulation of fertilizer use in the course of the EU harmonization process in the last decades. Meyer-Aurich et al. (2020) pointed to the current re-emergence of the debate on N taxation, which is fueled by the perceived lack of implementation of effective measures to reduce N use and its environmental damage. However, such taxing system is not unanimously accepted as best practice. Previous researches suggest that regulatory limits on N fertilizers compared to a tax-based economic instrument could actually achieve compliance more effectively and equitably (Lally and van Rensburg 2007; Buckley et al. 2016; Adenuga et al. 2020). This would be especially true for farms that are already operating at optimal fertilizing rates and in compliance with EU Nitrates based regulations (Lally and van Rensburg 2007; Buckley et al. 2016).

Demand elasticity for fertilizers (and pesticides) being fairly low, a very substantial tax would be required in order to achieve compliance with the stipulated application rates (Lally and van Rensburg 2007; OECD Environment Directorate 2020). Taxing the sales of inorganic nitrogen is thus considered to result in a larger compliance cost on farmers and on public authorities than would a regulatory measure. Furthermore, the tax is considered to result in inequities, as farms already in compliance with the Action Programme would incur substantial losses in farm income (Lally and van Rensburg 2007). Given the higher compliance cost and inequities generated by a tax-instrument compared to regulatory measures, it is considered unlikely that such a measure would be politically acceptable.

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1.2 Pesticides

1.2.1 Introduction

During the period of agricultural intensification, modern agriculture has progressively favored a dominant model that prioritizes productivity as the main objective. To maintain high level of production, agricultural production systems now rely heavily on the use of synthetic pesticides that protect the crops by controlling weeds, pathogens and animal pests (Bourguet and Guillemaud 2016; Carvalho 2017). These plant protection products (PPP) have been very successful in increasing agricultural yields. Their use has grown considerably since the middle of the twentieth century, becoming one of the most widely used and effective tools in agriculture (Bourguet and Guillemaud 2016).

Beside the benefits of pesticides in terms of agricultural production gains, concerns have been raised on the associated negative externalities touching a variety of dimensions, such as human health and the environment (Bourguet and Guillemaud 2016; OECD Environment Directorate 2020; Alliot et al. 2022).

By spreading in the environment, agrochemical residues from pesticides cause significant contamination of terrestrial and aquatic ecosystems (Carvalho 2017; OECD Environment Directorate 2020; Mamy et al. 2022). Large losses of biodiversity, such as insects, birds, amphibians, aquatic plants, fish, and small mammals, are associated with the presence of pesticide in the environment (Carvalho 2017; Mamy et al. 2022). Their translocation across all environmental compartments, as well as their persistent and bio-accumulative character, have made pesticides the cause of global and lasting environmental pollution.

The production of synthetic pesticides is energy intensive and can emit large amounts of greenhouse gases (GHG), thereby contributing to human-induced climate change (Cech, Leisch, and Zaller 2022). In turn, climate change is expected to increase the intensity of pesticide use due to, among others, an alteration of plants health and resistance (Delcour, Spanoghe, and Uyttendaele 2015).
Some studies tend to demonstrate, on the other hand, the positive impact of pesticide on GHG emissions, through the avoidance of land conversion (more pesticides used leads to less land needed to produce the same amount of agricultural goods) (Hughes et al. 2011).

The use of pesticides has a significant impact on human health as well. Human exposure to pesticides, through ingestion of contaminated food and water or direct contact, is linked to chronic illnesses such as cancer, and heart, respiratory and neurological diseases (OECD Environment Directorate 2020; EEA 2023). Farmers, rural workers, and

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rural families are more strongly affected by that risk, with many cases of intoxication being reported (Carvalho 2017). However, the full extent of health impacts related to pesticide exposure remains largely unknown, given the wide variety of chemicals applied (with their inherently different properties) and the different human exposure pathways (Fantke, Friedrich, and Jolliet 2012; Alliot et al. 2022).

Few of these consequences of pesticide use are confined to the farm on which they arise, the majority being ‘externalized’ to become a cost to society as a whole (Stoate et al. 2001).

1.2.2 Description of pesticide-related policies at EU-level

Over the decades, concerns about the impact of pesticides have emerged and grown as knowledge and evidence has been gathered by academic and other research institutions (Alliot et al. 2022). Recognizing these concerns, the EU has gradually built up a framework of legislation to authorize pesticides, promote their sustainable use and reduce the risk that they pose for human health and the environment (European Court of Auditors 2020). Table 4 highlights the most prominent EU policies for pesticides management in food systems, by chronological order.

The urgency of reducing dependency on pesticide is further stressed within the context of the European Green Deal, under the farm to fork strategy, zero pollution action plan and biodiversity strategy for 2030. These strategies set key targets, including a 50% reduction in the use and risk of chemical pesticides; a 50% reduction in the use of the more hazardous ones; at least 25% of the EU’s agricultural land to be under organic farming.

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Table 4. List of main EU policies enabling the internalization of externalities linked to pesticide in food systems.

Policy ID	Title	Topic	Date of entry into force	Date of application	History
Directive 2000/60/EC	Establishing a framework for Community action in the field of water policy	Water Framework Directive	Dec 2000	Dec 2003	
Regulation (EC) 396/2005	On maximum residue levels of pesticides in or on food and feed of plant and animal origin	Maximum Residue Levels	April 2005	Jul 2008	
Directive 2009/128/EC	Establishing a framework for Community action to achieve the sustainable use of pesticides	Sustainable Use Directive	Nov 2009	Dec 2011	
Regulation (EC) 1107/2009	Concerning the placing of plant protection products on the market	Market placing	Dec 2009	June 2011	Repealing Council Directives 79/117/EEC and 91/414/EEC
Directive 2009/127/EC	With regard to machinery for pesticide application	Machinery	Dec 2009	June 2011	Amending Directive 2006/42/EC
Regulation (EU) 2022/2379	On statistics on agricultural input and output	Statistics	Dec 2022	Jan 2023	Amending Regulation (EC) 617/2008 and repealing Regulations (EC) 1165/2008, (EC) 543/2009 and (EC) 1185/2009

The overarching goal of this pesticide framework is to ensure a high level of protection of both human and animal health and the environment, and at the same time to safeguard the competitiveness of the EU's agriculture. With these regulatory

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instruments, European authorities intend to mandate and control the environmental performance to be achieved by the Community's agriculture (Lefebvre, Langrell, and Gomez-y-Paloma 2015).

1.2.2.1 Directive 2000/60/EC – Water Framework Directive

Directive 2000/60/EC establishes a framework for Community action in the field of water policy. It includes measures to prevent or reduce pollution from agriculture, including environmental quality standards for pesticides in surface water.

Related policies:

- Directive 2008/105/EC on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council
- Directive 2013/39/EU amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy

1.2.2.2 Regulation (EC) 396/2005 – MRL

Regulation (EC) 396/2005 came into force in April 2005, setting pan-EU harmonized maximum pesticide residue levels[1] in or on plant- and animal-based food and feed, thereby regulating dietary exposure of consumers. It superseded the previous Council Directive 76/895/EEC relating to the fixing of maximum levels for pesticide residues in and on fruit and vegetables. As a result, since September 2008 national MRLs are no longer in force and only harmonized European legal limits apply (Karabelas et al. 2009).

1.2.2.3 Directive 2009/128/EC – SUD

The EU's regulatory framework for pesticides is grounded in Directive 2009/128 (known as the Sustainable Use Directive or SUD), which came into force in November 2009 to 1) establish a framework for the sustainable use of pesticide by reducing their risks to human health and the environment and 2) promote the use of integrated pest management and different techniques, such as non-chemical alternatives.

Regarding the first objective, the SUD introduced various requirements that needed to be transposed into the Member States' national legislation and subsequently implemented by their national authorities. These requirements included, for instance, banning aerial spraying but also reducing or banning the use of pesticides in various specific areas (Karabelas et al. 2009). Furthermore, the SUD required Member States to introduce "National Action Plans (NAP) aimed at setting quantitative objectives, targets,

[1] Maximum Residue Levels are the upper legal levels of a concentration for pesticide residues in or on food, or feed.

measures, timetables and indicators to reduce risks and impacts of pesticide use on human health and the environment and at encouraging the development and introduction of Integrated Pest Management (IPM) and of alternative approaches or techniques to reduce dependency on the use of pesticides" (Directive 2009/128/EC 2009a, introduction point 5). To support MSs in preparing their NAP, Regulation (EC) 1185/2009 adopted rules on the collection and dissemination of statistics on the sales and use of pesticides.

Regarding the second objective, the SUD was the first piece of EU legislation to introduce a set of principles for integrated pest management that should lead to a change in the use of pesticides by their users, mostly farmers (Directive 2009/128/EC 2018). It introduces two types of provisions (Lefebvre, Langrell, and Gomez-y-Paloma 2015):

- Obligations imposed to all the professional users of pesticides in the European Union to use pesticide properly (i.e. in compliance with the general principles of integrated pest management defined in annex III of the directive).
- Obligations imposed at Member State level (ensure that the general principles of IPM are implemented by all professional users and provide incentives to encourage professional users to implement crop or sector-specific guidelines for integrated pest management on a voluntary basis).

To address the increasing urgency of tackling pesticide use and dependency, the European Commission has committed to revising the directive on the sustainable use of pesticides, with a proposed regulation on the sustainable use of plant protection products currently under discussion (EEA 2023).

1.2.2.4 Regulation (EC) 1107/2009 – Market placing

Regulation (EC) 1107/2009 came into force in June 2011, with a view to structure the production and placement of PPPs on the market; it repealed Council Directive 91/414/EEC. While maintaining the basic principle based on protection of health (human and animal) and of the environment, the main objectives of the new regulation were oriented toward a better harmonization and simplification of the procedures concerning the regulation of pesticides, thereby reducing the costs for the private and public sector and strengthening the internal market (Pelaez, Silva, and Araújo 2013).

To do so, the Regulation sets out criteria to be met by pesticides manufacturers for the approval of active substances, safeners, synergists, co-formulants and adjuvants, which plant protection products contain or consist of, and rules to be followed for the authorization of PPP in Member States.

The placing of PPP on the market indeed relies on two main steps (Larras et al. 2022). First, all of the components of the PPP (active substances, synergists, safeners) have to be approved at the EU level and the co-formulants must not be on the list of unauthorized ones. Second, the commercial form of the PPP is assessed at a zonal level (within a group of Member States, namely North, Central, and South zones) prior to its authorization in one or several Member States of the targeted zone. To be approved, an active substance must show its efficacy towards the target species as well as its safety towards human and animal health, and environment. Also, it shall have no "armful effect on human health […], shall not have any unacceptable effects on plants or plant products […], shall not cause unnecessary suffering and pain to vertebrate […], and shall have no unacceptable effects on the environment" (European Commission 2009, Article 4). Therefore, the environmental risk assessment (ERA) of an active substance is a mandatory step, among others such as risk assessment for human health (Larras et al. 2022). The list of approved active substances is established in Commission implementing Regulation 540/2011.

Related policies:

- Regulation (EU) 2019/1381 on the transparency and sustainability of the EU risk assessment in the food chain.
- Commission Implementing Regulation (EU) No 540/2011 of 25 May 2011 implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards the list of approved active substances.

1.2.2.5 Directive 2009/127/EC – Machinery

Directive 2009/127/EC, known as the Machinery Directive, sets rules for the use of machinery for pesticide application. Under the Machinery Directive, manufacturers of machinery must fulfill certain essential requirements for the protection of the health and safety of persons and, where appropriate, domestic animals and property.

1.2.2.6 Regulation (EU) 2022/2379 – Statistics

Regulation (EU) 2022/2379 establishes an integrated framework for aggregated European statistics relating to the input and output of agricultural activities. It is part of a major programme aimed at modernizing EU agricultural statistics – the *Strategy for Agricultural Statistics for 2020 and beyond*.

1.2.3 Main policy instruments and mechanisms for the internalization of externalities at EU-level

The relevant legislation covering the impact of pesticides in food systems consists essentially of regulatory – command-and control (C&C) – instruments. The following evaluation section concentrates on these instruments, with a distinction between ex-ante risk assessment, market & post-market risk management – in the form of controls and labels –, as well as implementing instruments consisting of the implementation of

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National Action Plans (NAP). Table 5 lists the main instruments used in pesticide regulations, with references to the group of actors primarily targeted by the instrument, its ultimate beneficiaries, and the type of externalities addressed. When a type of externality is not fully detailed in the literature, the mention "undissociated" is used (for instance, pesticide legislations that broadly mention environmental impact without discerning sub-types such as climate change, toxicity, effects on biodiversity and ecosystems, etc.).

Since economic tax-based policy instruments are currently not mandate at EU-level, such instruments are not reviewed in the present paper.

Table 5. List of policy instruments used in the main EU policies regulating pesticide in food systems

Instrument category	Instrument topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
					Socio	Envi
C&C Ex-ante risk assessment	Approval of active substance	Regulation (EC)1107/2009	Agro-industry	Society at large	Food safety	Undissociated
	Approval of PPP	Regulation (EC)1107/2009	Public authorities	Society at large	Food safety	Undissociated
	MRL establishment	Regulation (EC)396/2005	Agro-industry	Consumers	Food safety	
C&C Market & post-market risk management	MRL controls	Regulation (EC)396/2005	Public authorities	Consumers	Food safety	
	Labelling	Regulation (EC)1107/2009	Agro-industry	Farmers	User's right	
C&C Implementing tools	National Action Plan	Directive 2009/128/EC	Public authorities & Farmers	Society at large	Food safety	Undissociated

The mention "undissociated" is used to report an impact that is not fully detailed in the literature.

1.2.3.1 Ex-ante risk assessment (active substances, PPP, MRLs) – IOE mechanism

The EU's requirement for an ex-ante assessment of the risks associated with the release of active substances and PPP, as well as the maximum pesticide residue levels allowed on food and feed, serves the purpose of minimizing adverse health and environmental effects due to pesticide use in agriculture. This instrument aims to reduce the social and environmental externalities caused by the use of pesticide by requiring industries (pesticides' manufactures and retail) to release products that comply with strict standards, thus minimizing the subsequent impacts of pesticides at farm-level.

1.2.3.2 Market & post-market risk management – IOE mechanism

1.2.3.2.1 MRL controls

Controlling compliance with MRL standards is an ex-post measure that allows for the management of food safety risks after the use of pesticides in agriculture. As such, this instrument supports the minimization of food safety issues associated with the use of pesticides by (1) encouraging an effective enforcement of EU standards and (2) identifying any non-compliance or infringements and taking action to limit their consequences on public health.

In addition, the ex-post management of food safety risks through the control of compliance with MRL standards provides a feedback mechanism for the ex-ante assessment of pesticide risks, allowing for improvements to be made to the assessment process based on the results of monitoring and evaluation. This instrument also contributes to enhancing consumer confidence in the safety of food and feed products by ensuring that they meet established standards.

1.2.3.2.2 Labelling

Labelling is an instrument used in agri-food systems to provide accurate information to producers and consumers. By ensuring the availability and transparency of information, labelling allows for freedom of choice, as users can make informed decisions about the products they purchase based on their values and preferences.

1.2.3.3 Implementing tool (National Action Plans) – IOE mechanism

National Action Plans aim to reduce the risks and impacts of pesticide use on human health, animals and the environment by encouraging the development and introduction of Integrated Pest Management and alternative approaches to reduce the dependency on pesticides. This instrument stimulates a change in the behavior of producers and fosters practices aligned with the objectives of the regulation.

National Action Plans act on both social and environmental externalities. On the social side, they can help improve health and food safety by improving the use of pesticides in agriculture. A better management of pesticides can lead to a reduction in health risks associated with the presence of pesticide residues in food, water and the environment (Alliot et al. 2022).

On the environmental side, National Action Plans can contribute to the reduction of various environmental externalities, including climate change, effects on biodiversity and ecosystems and toxicity, by improving the way pesticides are used and by reducing the dispersal of residues in the environment. Overall, they can contribute to the improvement of farming practices and the adoption of more sustainable approaches in agriculture, thereby increasing the resilience to environmental changes.

1.2.4 Evaluation of the impact of the policies instruments on the internalization of externalities

1.2.4.1 Ex-ante risk assessment – Active substances, PPP, MRLs

Before placing agrichemicals on the market, the EU requires a major consideration of their risks through a strict approval process for active substances and PPP (through Regulation (EC) 1107/2009), and the establishment of Maximum Residue Levels (Regulation (EC) 396/2005).

Overall, the REFIT[2] Evaluation of the EU legislation on plant protection products and pesticides residues (European Commission and ECORYS 2018) concluded that these instruments are effective and relevant, as they allow a higher level of harmonization across MSs, which enhances the functioning of the internal market and the protection of the health of consumers. This study demonstrates the positive impact of PPP and pesticides residues regulations on social, environmental and economic factors, mostly due to stringent criteria addressed at pesticide manufacturers for the approval of active substances. A number of studies however criticize the pesticide authorization process itself, arguing that, in practice, it has not achieved its objective of reducing the risk associated with pesticide use since unsafe pesticides are tsill allowed onto the EU market (Storck, Karpouzas, and Martin-Laurent 2017; Robinson et al. 2020). These studies claim that, while failing to directly target the negative environmental externalities linked to the use of pesticide in agricultural production systems, the regulation of PPP approval at EU level might have indirectly exacerbated negative **social, environmental, and economic** externalities.

1.2.4.1.1 Social impact

At social level, the application of the approval criteria for active substances has produced positive effects on **food safety**, with a reduction in public health costs (European Commission and ECORYS 2018). While this impact cannot be quantified, it is assumed that the non-approval, non-renewal, or withdrawal of substances based on health-based criteria since the introduction of the regulation has contributed to the avoidance of risks stemming from substances that are considered genotoxic, toxic to reproduction, or carcinogenic.

[2] The European Commission's regulatory fitness and performance programme (REFIT) aims to ensure that EU laws deliver on their objectives at a minimum cost for the benefit of citizens and businesses.

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While the application of approval criteria for active substances may have led to a reduction in negative health externalities, the setting of these criteria has been subject to much debate. In particular, the lack of **transparency** created by the limited requirements to publish data and information, the high level of expertise needed to understand the PPP authorization procedure and the lack of provision for public or stakeholder engagement during the different evaluation phases has hampered the acceptability of the process by society (Storck, Karpouzas, and Martin-Laurent 2017; Hamlyn 2019). Besides, the multi-actor decision chain of pesticide authorization, although originally designed to guarantee consensus about pesticide authorizations or bans, has resulted in growing suspicion because it is perceived as a potential source of conflict of interest (Storck, Karpouzas, and Martin-Laurent 2017).

Another aspect criticized in pesticide regulations for lack of transparency is the zonal system that was developed for pesticide authorization in Regulation (EC) 1107/2009, as it sheds little light on how the system was conceived (Hamlyn 2019).

Overall, these results suggest that EU pesticide regulations failed to deliver adequate public reporting, and therefore the possibility of public scrutiny. Improving public access and understanding of data and facilitating public participation in decision-making is necessary to enhance **trust** in pesticide authorization process. De Boer, Morvillo, et Röttger-Wirtz (2023) argue that as a result of legislative reform, the **transparency** of EU agency science is now approached more proactively, thereby strengthening the overall legitimacy of expert-based measures in EU risk regulation.

1.2.4.1.2 Environmental impact

At environmental level, the regulation of PPP approval seems to have similarly conducted to both positive impact due to stringent rules for the application of active substance, and negative impact due to related procedures. The non-approval or non-renewal of substances due to environmental concerns has helped to avoid risks to groundwater, soil and wildlife, thereby reducing negative externalities linked to **toxicity** and direct effects on **biodiversity** and ecosystems (European Commission and ECORYS 2018).

Nonetheless, two mechanisms linked to the authorization procedure might alternatively induce **toxicity** for biodiversity and ecosystems. First, the environmental risk assessment (ERA) fails to consider the full range of risks linked to pesticide use, including risks from transformation products deriving from the degradation of active substances in the environment, cumulative effects, sublethal exposure, chronic toxicity (Storck, Karpouzas, and Martin-Laurent 2017; Schäfer et al. 2019; Sgolastra et al. 2020; Weisner et al. 2021). As a result, harmful molecules can slip through the assessment and enter the environment. Second, the very slow pace for reassessment process results in the continued use of PPP that are largely acknowledged as harmful. As illustrated by Storck, Karpouzas, et Martin-Laurent (2017), it is not unusual to have a 20 to 30 years' time lag between the development of a new pesticide and the awareness demonstration of its harmfulness by academic studies. This is a long period of time during which the environment and human health are exposed to potential risks associated to these pesticides.

1.2.4.1.3 Economic impact

At economic level, the regulation of PPP approval might indirectly induce effect on **market structure**. Following the implementation of ERA, hazardous substances have been banned from the EU, forcing pesticide manufacturers to develop new classes of active substances. This continuous introduction of new products and bans of old ones has created a pesticide market which is under constant evolution (Storck, Karpouzas, and Martin-Laurent 2017). As more test and data are required for a PPP to be approved, the procedure generates additional costs that affect sectoral competitiveness through increased R&D investments (Chapman 2014), as well as the emergence of new markets, e.g. biocontrol active substances (Robin and Marchand 2019; Chandler et al. 2011). The REFIT evaluation of EU legislation on plant protection products and pesticides residues (European Commission and ECORYS 2018) estimated at 11,7% the increase in overall costs of development of a new plant protection product resulting from the increased regulatory requirements between the periods 2005-08 and 2010-14. They further acknowledged that it is particularly difficult for smaller companies to meet the requirements of the legislation and to bear the associated **costs** of research and development. The data requirements and procedures induced by the legislation are of particular concern for SMEs and has led to a negative trend in the number of micro and small enterprises and the level of **employment** in these enterprises (European Commission and ECORYS 2018). This is in line with Drogué et DeMaria (2012) who directly associate with MRL standard setting higher costs due to stricter regulations to comply with.

While some argues that the EU pesticide legislation would reduce the availability of PPPs in Europe (Chapman 2014), thereby affecting the competitiveness of EU agriculture, this claim cannot be supported by quantitative evidence (European Commission and ECORYS 2018).

In 2019, the European Institutions adopted Regulation (EU) 2019/1381, effective in March 2021, to increase the transparency and sustainability of the EU risk assessment in the food chain. This new regulation is however anticipated to have some negative economic impact related to **knowledge capital spillover** and **employment** (Chatzopoulou, Eriksson, and Eriksson 2020). The significant focus of the regulation on risk communication through, among others, automatic publication of all studies and stakeholders' consultations, while important, raises concerns in the industry concerning confidentiality and property rights with implications on research and innovation in the sector. Furthermore, early publication of information could jeopardize innovation and jobs creation as the industry would be reluctant to continue investing in EU countries (Chatzopoulou, Eriksson, and Eriksson 2020).

1.2.4.2 Market & post-market risk management – Controls and Labelling

The management of risks related to pesticides at market and post-market level is instrumentalized through controls and labelling requirements.

Controls of pesticides levels in or on food and feed of plant and animal origin is an important instrument to ensure MRLs are respected and to guarantee consumers' health. However, the scope of our literature review did not allow us to find articles on the specific impact of controls and surveillance tools for MRL within the EU. The following paragraph focuses on the social impact of labelling (no environmental and economic impacts could be retrieved from the assessed literature).

1.2.4.2.1 Social impact

Regulation (EC) 1107/2009, which governs the placing of plant protection products on the market in the European Union, includes specific provisions regarding packaging, labelling, and advertising. These provisions aim to ensure that users are able to safely and effectively use plant protection products, while also minimizing potential risks to human health and the environment. These provisions provide positive social outcomes as regards consumer/user rights. Harmonized obligatory instructions for operators to wear personal protective equipment and other harmonized risk mitigation measures contribute to a safe use of PPP and to more **transparency** and comprehensibility (Lichtenberg et al. 2015).

1.2.4.3 Implementing tools – National Action Plans

The EU's Sustainable Use of Pesticides Directive (2009/128/EC) requires Member States to develop NAPs to promote the use of Integrated Pest Management (IPM) and reduce the risks associated with pesticide use. While the EU provides guidance on the content and format of NAPs, the development and implementation of NAPs is left to the discretion of each Member State. The EU relies on a cooperative and participatory approach to implement NAPs, where stakeholders are involved in the development and implementation of measures to promote the use of IPM. In 2021, Helepciuc et Todor (2022) stressed the minimal effect brought by the Sustainable Use Directive in homogenizing different states' approaches to develop their NAPs. Indeed, the Sustainable Use Directive defined an overarching objective (the sustainable use of pesticides), three goals (risk reduction, promotion of IPM, low-risk alternatives to pesticides), and a set of compulsory action areas. Still, it proposed no quantifiable means to assess progress and no mandatory targets. Instead, each EU Member State was supposed to propose measurable objectives, targets, measures, and indicators that would allow for verifying its NAP implementation. As a result, significant differences exist among countries' NAPs (Helepciuc and Todor 2021). Without an EU-level coherent methodology for creating the NAPs and a set of comparable indicators to assess progress on each measure proposed, it is very challenging to evaluate the impact of the Sustainable Use Directive and its NAP instrument.

1.2.4.3.1 Social and environmental impacts

In 2019, the European Commission published its first calculation of two Harmonized Risk Indicators (HRI). HRI 1 is a measure of the acute toxicity of a pesticide to humans. It consists of measuring the use and risk of pesticides based on pesticide sales data. HRI 2 is a measure of the chronic toxicity of a pesticide to humans, which is calculated based on the number of emergency authorizations reported to the Commission by Member States. In this first calculation, data showed a decrease of 17% in HRI 1 in the use and risk of pesticides but a 56% increase in HRI 2 in the evolution of emergency authorization. Helepciuc et Todor (2022) consider these results as mild progress raising important questions about the overall capacity of the EU MSs to achieve notable success in decreasing the risks to **public health** and the **environment** posed by synthetic pesticides.
Moreover, the methodology underpinning these indicators has been criticized by key actors, such as the European Court of Auditors (European Court of Auditors 2020) and the German Environment Agency (Bär et al. 2022)

1.2.4.3.2 Economic impact

The NAP can have positive economic impact by fostering **knowledge capital** spillover, as the requirement for Member States to conduct crop protection activity using a system of Integrated Pest Management is likely to foster more investment in IPM research and development (Lamichhane, Messéan, and Ricci 2019; Hillocks 2012). The transposition of the NAP requirement into French law, for instance, resulted in the development of the Ecophyto plan, which has translated into dynamic and significant advances made by research. This dynamism is expected to produce a corpus of scientific knowledge and technical innovations which can contribute to the expected transition toward a low-input crop protection system (Lamichhane, Messéan, and Ricci 2019).

1.2.4.4 Synthesis of EU pesticide policies' impacts on social, environmental and economic factors

Table 6 provides a synthesis of the impacts of EU pesticide policies and their instruments on social, environmental and economic externalities, as suggested by the literature review.

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Table 6. Synthesis of reviewed positive (+), negative (-), and non-directional (/) impacts of EU pesticide policy instruments on social, environmental and economic factors

	Social	Environmental	Economic
Ex-ante risk assessment	(+) Public health (-) (/) Transparency	(+) Biodiversity (-) (/) Toxicity	(+) (-) Compliance costs (-) Employment (/) Market structure
Market & post-market risk management	(+) Transparency (-) (/)	(+) (-) (/)	(+) (-) (/)
Implementing tools	(+) (-) (/) Public health	(+) (-) (/) Undissociated	(+) Knowledge capital (-) (/)

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1.3 Genetically Modified Organisms

As a foreword, it should be noted that the regulation of Genetically Modified Organisms (GMOs) and associated issues are significantly impacted by public opinion, which remains largely unfavorable in the EU. Assessing the impact of policies on GMO externalities is further complicated by the existence of a wide range of studies and opinions on the subject.

1.3.1 Introduction

Since commercially introduced to farmers in 1996, genetically modified (GM) crops have generated a great deal of controversy, with major debates polarizing the scientific community, consumers, farmers, and policymakers (Maghari and Ardekani 2011; Garcia-Yi et al. 2014; Tsatsakis et al. 2017; Agarwal and Singh 2020). Various socio-economic and environmental motivations are given either in favor or in opposition to this agricultural biotechnology.

At socio-economic level, GM crops are considered by its defenders as a solution to ensure food security in an ever-growing world (Raybould and Poppy 2012). They are expected to bring positive changes in yield, either through increased plant productivity or through increased resistance to stresses, thereby improving economic returns for farmers (Raybould and Poppy 2012; Garcia-Yi et al. 2014; Tsatsakis et al. 2017). They are also perceived as beneficial for health as they are expected to bring additional nutritional quality to crops (Raybould and Poppy 2012).
Various studies point however to other risks for human health, due to associated food allergies, antibiotic resistance or nutritional changes (Maghari and Ardekani 2011). GM crops are also accused of negative economic impact, due to their different price premium (Munro 2008). As such, non-GM fields infiltrated with a GM variety will not reap the same price premium as crops guaranteed GM free. Besides, important concern is raised about Intellectual Property Rights, as GM crops are patented by Agri-business companies, which could lead to monopolization of the global agricultural food and controlling distribution of the world food supply (Maghari and Ardekani 2011).

At environmental level, GM crops are defended as being highly beneficial for the environment due to their potential to face the growing scarcity of environmental resources and to reduce the use of chemical inputs (Maghari and Ardekani 2011; Garcia-Yi et al. 2014). They are further acknowledged for their contribution to virtuous farming practices allowing for reduced soil erosion, runoff, and greenhouse gas emissions (Garcia-Yi et al. 2014).
On the other hand, this technology is accused of bringing grave risks of destructive and irreversible genetic pollution (Maghari and Ardekani 2011). In particular, concern is raised on the emergence of superweeds and superpests and the decline in biodiversity

that are associated with GM crops. Furthermore, the transfer of GM traits to crops might have undesired ecological consequences by giving them a selective advantage over wild plants in natural ecosystems (Munro 2008; Ehlers 2011). Such studies therefore urge to proceed with caution when dealing with GMOs (Maghari and Ardekani 2011).
It should be noted that the 2012-2015 EU-funded GMO Risk Assessment and Communication of Evidence (GRACE) project aimed, among others, at assessing the overall debate on GM safety assessment, concluded that no effects of insect resistant GM crops (tested with Bt maize, which is authorized in the EU) were documented on non-target organism populations, such as beetles and butterflies or to soil microorganisms, when compared to natural maize (Grace project 2016).

The debate surrounding the potential socioeconomic and environmental impacts of GM crops, food, and feed remains a contentious issue, and despite efforts to address concerns and objectify opposition, arguments and disagreements persist.

To deal with the perceived potential risks and uncertainties of GM crops, food and feed, the EU adopted a precautionary approach. Two main regulations were passed with the objectives to protect human health and the environment when (a) carrying out the deliberate release into the environment of genetically modified organisms for any other purposes than placing on the market within the Community (Directive 2001/18/EC 2001), and (b) placing on the market genetically modified organisms as or in products within the Community (Regulation (EC) 1829/2003 2003).

1.3.2 Description of GMO-related policies at EU-level

The regulation of GMOs gained attention in the EU in the late 1980s. The first Council Directive 90/220/EEC covered their deliberate release into the environment and market introduction. Following a number of food crises and the requirement to realign with World Trade Organization law, several Member States asked for a revision of the approval process and requirements for placing GMOs on the market by the end of the 1990s (D. Eriksson et al. 2020). In response to this, a new legal framework repealed Council Directive 90/220/EEC with Directive 2001/18/EC on the deliberate release into the environment of GMOs. Since its publication, the Directive has been amended and complemented several times to include, among others:

In 2003	Regulation (EC) 1829/2003	Specifications for GM food and feed (GMF)
	Regulations (EC) 1830/2003 and (EC) 65/2004	Labelling and traceability requirements

	Regulation (EC) 1946/2003 Regulations (EC) 178/ 2002 and (EC) 1829/2003 Commission Recommendation of 23 July 2003	Rules on transboundary movements A centralized authorization procedure for GMOs Coexistence recommendations
In 2004	Directive 2004/35/C	A liability regime for environmental and biodiversity damages
In 2009	Directive 2009/41/EC	Provisions on contained use of genetically modified micro-organisms
In 2010	Commission Recommendation of 13 July 2010	A second version of recommendation for coexistence measures
In 2015	Directive (EU) 2015/412	Provisions to allow Member States to restrict or ban GMO cultivation in their territory
In 2018	Directive (EU) 2018/350	An update of the environmental risk assessment process
In 2019	Regulation (EU) 2019/1381	Transparency and sustainability of the EU risk assessment in the food chain

These main pieces of legislation are supplemented by various implementing rules and by recommendations and guidelines on more specific aspects, resulting in a large number of GM-related policies in the EU. The present evaluation focuses on policies considered as the main, overarching GM legislations affecting food systems. They are presented in Table 7, by chronological order.

Table 7. List of main EU policies enabling the internalization of externalities linked to GMO in food systems

Policy ID	Title	Topic	Date of entry into force	Date of application	History
Directive 2001/18/EC	On the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC	Deliberate release	April 2001	October 2002	Repealing Council Directive 90/220/EEC
Regulation (EC) 1829/2003	On genetically modified food and feed	GM Food & Feed	November 2003	April 2004	
Regulations (EC) 1830/2003	Concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC	Traceability and labelling	November 2003	April 2004	
Regulation (EC) 1946/2003	On transboundary movements of genetically modified organisms	Transboundary movements	November 2003		

Following the establishment of this framework on GMOs, risk assessment and risk management are considered largely harmonized at the EU level. However, the institutional environment for planting GM crops in Europe is heterogeneous across Member States (Beckmann, Soregaroli, and Wesseler 2006; D. Eriksson et al. 2020). While, in 2003, the European Commission stated that "no form of agriculture, be it conventional, organic or agriculture using genetically modified organism, should be excluded in the European Union", it decided to follow the principle of subsidiarity, meaning that Member States can adopt their own rules governing coexistence (European Commission 2003). From this principle results many divergences in the management of GMOs across European countries. Additionally, under Directive (EU) 2015/412, since 2015 a Member State may provisionally restrict or prohibit the use and/or sale of a particular GMO on their territory if new findings indicating potential environmental or health risks of the organism appear.

1.3.2.1 Directive 2001/18/EC – Deliberate release

Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms is the text of reference regulating the approval process for the cultivation and use of GM crops in the Member States. Its objective is to establish a comprehensive framework for the safe use and release of genetically modified organisms into the environment within the European Union (Directive 2001/18/EC 2001).

The directive requires that any GMO intended for release into the environment undergoes a thorough risk assessment, following a prescribed methodology, taking into account potential risks to human and animal health and the environment. In addition, the directive establishes a system of notification and authorization for the release of GMOs, which includes a consultation process with the public and relevant stakeholders. It also requires that appropriate monitoring and post-market surveillance of GMOs be carried out to ensure ongoing safety.

1.3.2.2 Regulation (EC) 1829/2003 – GM food & feed

Regulation (EC) 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed is a regulation that specifically deals with the authorization and labelling of genetically modified food and feed products in the EU. It provides a harmonized and centralized procedure for the scientific assessment and authorization of GM food and feed. Furthermore, the regulation requires labelling of all GM food and feed, which contain or consist of GMOs or are produced from or contain ingredients produced from GMOs.

Related policies:

- Commission Regulation (EU) No 619/2011 of 24 June 2011 laying down the methods of sampling and analysis for the official control of feed as regards presence of genetically modified material for which an authorization procedure is pending or the authorization of which has expired.

1.3.2.3 Regulations (EC) 1830/2003 – Traceability & labelling

The traceability and labelling regulation provides a harmonized EU system for identifying GM products throughout the supply chain with the objective of facilitating accurate labelling in accordance with Regulation (EC) 1829/2003 (UK Food Standards Agency 2003). This regulation mandates that food and feed products containing GMOs (with a threshold of 0.9%) must be labelled with the words ‘genetically modified’ or ‘produced from genetically modified (name of the organism)’ (Regulation (EC) 1830/2003 2003). It is worth noting that, while the use of GM animal feed is regulated under EU law, the EU does not require products derived from animals fed with GM feed to be labeled as such.

1.3.2.4 Regulation (EC) 1946/2003 – Transboundary movements

Regulation (EC). 1946/2003, which entered into force in November 2003, applies to the transboundary movements of all GMOs that may have adverse effects on the conservation and sustainable use of biological diversity, also taking into account risks to human health.

1.3.3 Main policy instruments and mechanisms for the internalization of externalities at EU-level

In the European Union, strong public opposition to GMOs contributed to the development of one of the strictest GMOs legislations worldwide. In order to meet societal concerns relating to the safety of GM crops, the EU adopted a precautionary principle position, with rigorous command-and-control (C&C) measures requiring robust ex-ante risk assessment, as well as ex-post risk management at production level (co-existence measures) and at market and post-market level (monitoring, traceability and labelling).

In the following evaluation, we evaluate the effectiveness of two main instruments related to policies compiled in Table 7 in dealing with externalities of GMOs:

1. ex-ante risk assessment and
2. market and post-market risk management (monitoring, and traceability and labelling)

Risk management at production level, established through co-existence measures for the cultivation of GM crops, are not assessed here. As the European Commission follows the subsidiarity principle for the implementation of legal coexistence frames, such measures are handled by Member States. As a result, there are strong discrepancies between MSs, with some having no coexistence measures at all, and others having ex-ante measures (isolation distance) and/or ex-post liability measures (Devos et al. 2009). Co-existence is therefore considered out of scope in the assessment of EU-wide impact of regulations on externalities.

Table 8 lists the main instruments used in GMO regulations, with references to the group of actors primarily targeted by the instrument, its ultimate beneficiaries, and the type of externalities addressed. When a type of externality is not fully detailed in the literature, the mention “undissociated” is used.

Table 8. List of policy instruments used in the main EU policies regulating GMO in food systems

Instrument category	Instrument topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
					Socio	Envi
C&C Ex-ante risk assessment	GM crops, food and feed risk assessment	Directive 2001/18/EC; Regulation (EC) 1829/2003	Public authorities	Society at large	Human health; Animal health	Undissociated
C&C Market & post-market risk management	Monitoring & Surveillance	Directive 2001/18/EC; Regulation (EC) 1829/2003	Agro-industry; Farmers	Society at large	Human health; Animal health	Undissociated
	Traceability & labelling	Regulation (EC) 1829/2003; Regulation (EC) 1830/2003; Regulation (EC) 1946/2003	Agro-industry; Farmers	Consumer	Consumer right	

The mention "undissociated" is used to report an impact that is not fully detailed in the literature.

1.3.3.1 Ex-ante risk assessment (GM crops, food and feed) – IOE mechanism

The core of the GMO legislation, based on regulation 2001/18/EC, is an approval process consisting of a pre-release authorization (Christiansen, Andersen, and Kappel 2019). A GMO can be authorized either for cultivation on EU territory, or it can be authorized for use in food and feed that is sold on the European market. The process begins with a comprehensive risk assessment conducted by the applicant, who is typically the developer or producer of the GMO. The applicant must provide scientific data and studies to assess the potential risks associated with GMO, including its potential effects on human health, animal health, and the environment.

The ex-ante risk assessment instrument therefore aims to reduce the social and environmental externalities caused by the use of GMOs by requiring manufacturers and importers to release products that comply with strict standards, thus minimizing the subsequent impacts of GMOs at farm-level.

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1.3.3.2 Market & post-market risk management – IOE mechanism

1.3.3.2.1 Monitoring & Surveillance

Monitoring and surveilling compliance with GMO requirements is an ex-post measure that allows for the management of risks for human health, animal health, and the environment after the release of GMOs. As such, this instrument supports the minimization of social and environmental externalities associated with GMOs by (1) encouraging an effective enforcement of EU standards and (2) identifying any non-compliance or infringements and taking action to limit their consequences on public and environmental health.

1.3.3.2.2 Traceability & labelling

Labelling is an instrument used in agri-food systems to provide accurate information to producers and consumers. By ensuring the availability and transparency of information, labelling allows for freedom of choice, as users can make informed decisions about the products they purchase based on their values and preferences. This instrument is supported by the existence of a traceability mechanism to monitor movements of products along the value chain.

1.3.4 Evaluation of the impact of the policies instruments on the internalization of externalities

1.3.4.1 Ex-ante risk assessment – GM crops, food and feed

The EU authorization procedure is considered quite burdensome and generates lengthy delays in the authorization process, thereby hindering widespread adoption of genetically modified crops, food and feed (Graff, Hochman, and Zilberman 2009; Smith 2011; Park et al. 2011; Raybould and Poppy 2012; Smart, Blum, and Wesseler 2015; Christiansen, Andersen, and Kappel 2019; Wesseler 2019). As a result, only one GMO is currently authorized for cultivation in the EU (Monsanto's MON810 pest resistant maize), though no application for authorization has ever been rejected by the EC (Smart, Blum, and Wesseler 2015; Christiansen, Andersen, and Kappel 2019). For food and feed use, a larger number of GMOs (around 90) are authorized (European Commission 2023a). Christiansen, Andersen, et Kappel (2019) explain the difference between the number of authorizations for cultivation and for food and feed by political factors, due to the reduced opposition to food and feed use compared to cultivation, and by the fact that the environmental risk assessment for food and feed use is less extensive than for cultivation.

In the U.S., by comparison, the authorities have adopted a quite permissive approval policy for GM food products, resulting in a much larger number of crops approved for cultivation. Various reasons are advanced to explain such discrepancy between the EU and other regions of the world, including strong negative consumer perception and citizens' mistrust of the integrity of regulatory decisions, continuous scientific uncertainty arising from the lack of consensus, political uncertainty due to overlaps between regulations (i.e. pesticide and GMOs regulations), or powerful political and non-political opposition forces (Graff, Hochman, and Zilberman 2009; Ehlers 2011; Raybould and Poppy 2012). Furthermore, heterogeneity across Member States' legislations on GM crops cultivation is considered to have been detrimental to the uptake of GMOs (Smith 2011). Indeed, importers and cultivators must balance anti-GMO legislation, such as that in Hungary, against pro-GMO legislation in other European countries, such as Romania (Smith 2011).

In an attempt to improve the authorization process, an amendment to regulation 2001/18/EC was introduced by the EC in 2015 (Directive (EU) 2015/412) to permit individual MSs to opt-out of the authorization of the cultivation of GMOs on their territory for reasons other than safety. In effect, this means that individual MSs are allowed to ban the cultivation of a given GMO even if it has been judged safe by EFSA. Christiansen, Andersen, et Kappel (2019) highlight in particular the de-harmonizing impact of that amendment on EU GMO regulation and the associated shift of responsibility from the EU to Member States.

Overall, by – de facto – acting as a ban for GMOs cultivation in EU Member States, the ex-ante risk assessment instrument set in place in Directive 2001/18/EC **prevents the widespread emergence of externalities** directly associated with the cultivation of GM crops. The limited opportunity for GMOs adoption in EU generates both direct and indirect economic impacts for European GMOs stakeholders that are set aside from the worldwide GM market. For instance, Park et al. (2011) estimate that delays to cultivation approvals in the EU directly costs its farmers between €443 million and €929 million each year[3]. Besides, divergences among Member States' perception and management of the risks associated with GM crops, feed and food, results in a heterogenous regulatory environment across EU, which has a number of socio-economic and environmental impacts.

1.3.4.1.1 Economic impact

At economic level, the decentralized heterogenous approaches to regulate the use of GM crops, food and feed has an **effect on the structure of the EU agricultural market**, since the GM goods produced in a country can no longer **freely move** in the market (Smith 2011). Besides, it can generate differences in the **competitivity** of European producers (Raybould and Poppy 2012; M. Eriksson et al. 2018). For instance, in Sweden where compound feed is mostly manufactured from non-GM soy, the cost of animal production is reported to be 15% higher than in other EU member states (M. Eriksson et

[3] This study received funding from Monsanto.

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al. 2018). On the other extreme, EU member states that rely on GM soy for compound feed, such as Belgium, Netherlands, Portugal and Spain, have lower costs of production, which makes their animal farmers more competitive (M. Eriksson et al. 2018). Finally, the divergence in approaches to regulation of GMOs among countries and the EU zero tolerance policy toward non-approved GMO imports are considered to inhibit **trade** (Philippidis 2010; Raybould and Poppy 2012; Smart, Blum, and Wesseler 2015; Pavleska and Kerr 2020). By disrupting imports, this trade effect could in turn compromise the competitiveness of the EU livestock sector, which would jeopardize agricultural incomes and **employment** (Raybould and Poppy 2012; Smart, Blum, and Wesseler 2015).

In addition to its direct effects on the European agricultural market, the strict and heterogenous ex-ante GMO regulation in the EU has economic consequences for biotechnology industries. The highly complex risks assessment demanded by the EU results in high **costs** for companies that must comply with this requirement (Maghari and Ardekani 2011; Ricroch, Boisron, and Kuntz 2015; Smart, Blum, and Wesseler 2015; Wesseler 2019). Besides, the risk assessment procedure has faced criticism for not being based on sound scientific knowledge, but instead for responding to political agendas (Ricroch, Boisron, and Kuntz 2015; Christiansen, Andersen, and Kappel 2019; Wesseler 2019). There has therefore been calls to simplify this procedure, which would result in lower transaction costs for private companies.

These transaction costs incurred by the authorization procedure, combined with its complexity, its time-consuming character and the highly uncertain outcome, may discourage investments in the GM technology by the private sector (Graff, Hochman, and Zilberman 2009; Maghari and Ardekani 2011; Raybould and Poppy 2012; Zepeda, Wesseler, and Smyth 2013; Smart, Blum, and Wesseler 2015; Wesseler 2019). This disincentive for investing in R&D represents a negative **knowledge capital spillover** leading to reduced innovation. These transaction costs further impact the **structure of the biotechnology market**, due to the resulting high costs of entry, which have led individuals and companies to either exit the industry or relocate their research and development activities (Graff, Hochman, and Zilberman 2009; Smart, Blum, and Wesseler 2015; Wesseler 2019). In addition to directly compromising small and medium sized companies, those costs are reported to support industry concentration within large companies, as illustrated by the recent mergers of Syngenta and China National Chemical Corporation (ChemChina), DOW and Dupont, and Bayer and Monsanto, which are expected to reduce R&D and operational costs (Wesseler 2019). These effects on the market in turn reduce the development of **human capital**, expertise, investment and employment opportunities and further degrades innovative capacity (Graff, Hochman, and Zilberman 2009; Raybould and Poppy 2012; Smart, Blum, and Wesseler 2015; Wesseler 2019).

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A final economic consideration pertains to the transaction costs incurred to public authorities for complying with the regulation. Raybould et Poppy (2012) consider that millions of euros are needed every year to maintain the EU regulatory bureaucracy for GM crops, including parts of EFSA, competent authorities in member states and public research into human and environmental risks. They further point to the potential waste of time and money this would represent, should GM crops be considered as politically unacceptable in the EU, regardless of scientific evidence.

According to the view of Raybould et Poppy (2012), if this money has any chance of being well spent, there must be a policy that GM crops can be grown in the EU if they meet certain criteria, and that scientific analysis of the risks posed by cultivation will play some part in the decision for particular products. If cultivation of GM crops is politically unacceptable in the EU, then scientific analysis of the risks of GM crops will have no effect on decision-making and is thus considered a waste of time and money.

1.3.4.1.2 Social impact

At social level, the amendment allowing EU member states to restrict or prohibit the cultivation of genetically modified plants on their territory is thought to complicate **information for consumers** (Smith 2011). This complexified information sharing is related to the need for producers, manufacturers, and corporations to conform to varying standards, resulting in potentially confusing or conflicting information for consumers. Besides, having separate markets, both pro-GM and anti-GM affects the **availability of choices** faced by producers and consumers (Desquilbet and Poret 2014). Heterogeneity in national markets therefore means heterogeneity in the choice available to these producers and consumers from one country to another.

The time taken for a GM crop's application successfully passing through the political step of the overall authorization process is considered by some authors of socio-economic importance as the quicker it takes, the sooner society can benefit from using it (Graff, Hochman, and Zilberman 2009; Smart, Blum, and Wesseler 2015; Wesseler 2019). The delay imposed by the European regulatory framework is therefore sometimes considered to represent a **missed opportunity of societal benefit**.

1.3.4.1.3 Environmental impact

At environmental level, some authors report that the complicated risk assessment procedures, which acts as disincentive for companies to invest in further research and development, leads to slower innovation, ultimately affecting the **benefits** for consumers and the **environment** (Graff, Hochman, and Zilberman 2009; Wesseler 2019). Others, like Chvátalová (2019), rather argue for the pertinence of the safety assessment procedure of GM crops in the EU to successively evaluate **ecological risks**, such as biosafety of bee pollinators.

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1.3.4.2 Market & post-market risk management – Monitoring & Surveillance

Applications for placing on the market of genetically modified organisms for import, food, feed and processing under Directive 2001/18/EC and Regulation (EC) 1829/ 2003, have to include a post-market monitoring plan. This monitoring plan includes the need for case-specific monitoring, designed to monitor known adverse effects identified in the environmental risk assessment, and a general surveillance system, designed to identify the occurrence of unanticipated adverse effects on human and animal health or the environment. In addition to its role in monitoring adverse effects, the monitoring system is required to ensure that GMO labelling and traceability requirements of Regulation (EC) 1830/2003 (EU, 2003b) are met (Kleter et al. 2018).

The surveillance system is crucial for the proper regulation of GMOs, as it helps to ensure the safety of GMOs and minimize any potential risks associated with their use. However, because of the very strict GMOs regulatory environment in the EU, there is very limited data available to assess the long-term impacts of GMOs on social and environmental factors. The capacity to design effective surveillance systems is therefore doubted considering the shortage of evidence for adverse impacts related to GMOs and the lack of a specific test to confirm these effects (Wilhelm and Schiemann 2007; Vince et al. 2018).

Besides the lack of data weakening the design of an effective surveillance system, the harmonization of that system represents another challenge. As Directive 2001/18/EC on the release of GMOs proposes to use existing surveillance networks for the monitoring of environmental impacts of GM plant cultivation, this raises the issue of standardization, since European and national institutions are poorly harmonized concerning their scopes, tasks and methods (Wilhelm and Schiemann 2007).

Despite these concerns, the post-market monitoring plan required in Directive 2001/18/EC should encourage the **knowledge spillovers** between national GMO monitoring stakeholders, and with other sectors (Wilhelm and Schiemann 2007). This exchange of information and knowledge can help to improve the safety assessment and monitoring of GMOs, particularly as new products and technologies are developed. It can also promote greater public confidence in the safety of GMOs, which is important for the acceptance of these products.

1.3.4.3 Market & post-market risk management – Traceability & labelling

1.3.4.3.1 Social impact

Traceability and labelling for GMOs are both practical tools in support of the post-marketing monitoring plan. Traceability provides a safety net by facilitating both the withdrawal of products where unforeseen adverse effects on human or animal health

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or the environment have been observed, as well as the targeting of monitoring to examine potential effects on the environment (Kleter et al. 2018). It further enables the control of labelling claims, which ensure the availability of accurate information to producers and consumers as a mean to ensure **freedom of choice** (Vaasen, Gathmann, and Bartsch 2006; Maghari and Ardekani 2011; Desquilbet and Poret 2014; Kleter et al. 2018). This labelling requirement has been made mandatory in the EU In light of the considerable and lasting societal opposition to GMOs (Desquilbet and Poret 2014).

In practice, ensuring traceability and labelling all along the food chain is a huge challenge. In their evaluation of the traceability of GM maize grown in Spain, Kleter et al. (2018) confirm that data on the specific GM product present in feed is rapidly lost downstream in the subsequent stages of mixing and processing feed ingredients from various sources. While a large share of feed materials is labelled as containing GM materials, there seems to be a global lack of comprehensive, **publicly accessible data** that provides detailed information regarding the GM vs. non-GMO origin of feed materials at the final consumer level.

As a final consideration of the social impact of traceability and labelling, it should be noted that some authors criticize the overall relevance of mandatory risk-based GMO labels, similar to those required in the EU, as it is not perceived as providing valuable information to consumers (Gruère 2006; Premanandh 2011; Smyth, Kerr, and Phillips 2017; Christiansen, Andersen, and Kappel 2019). Christiansen, Andersen, and Kappel (2019) argue for instance that such labels are senseless, since they do not pick out a type of food that is particularly risky. They base this opinion on the absence of observation of adverse effects after more than 20 years of widespread use of safety-approved GMOs. They conclude that the desire to avoid GMOs does not constitute a sufficiently important interest to consumers to justify mandatory labelling. What is more, if there is a demand for GMO-free products, they expect farmers and retailers to voluntarily label their products in order to meet that demand specifically.

In their study on the impact of labelling on international trade, Smyth, Kerr, and Phillips (2017) suggest that, given the cost of segregating GM from non-GM goods, firms might seek a soft option for GM labelling, using the vague 'may contain' GMOs claim. They argue that such a reaction was already observed in the case of allergens such as peanuts when strict labelling and liability regulatory regimes were put in place. As a result, the labelling information is considered to be of little use to consumers.

1.3.4.3.2 Environmental impact

As a tool providing data for GM crop monitoring purposes, traceability and labelling requirements are considered beneficial in ensuring the overall environmental safety (Vaasen, Gathmann, and Bartsch 2006).

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1.3.4.3.3 Economic impact

Traceability and labelling instruments have been criticized for their economic implications. They generate higher **transaction costs** to ensure compliance, as the identification and quantification of GM material in products inevitably entails additional costs for the industry (Gruère 2006; Devos et al. 2009; Smith 2011; Maghari and Ardekani 2011; Smyth, Kerr, and Phillips 2017). These transaction costs may be further reinforced by the heterogeneity existing among national GMO regulations that may lead to the need for case-specific adaptation of the traceability and labelling (Smith 2011). Furthermore, there is concern that obligatory labelling, and its related cost, would hold back innovation in the biotechnology industry, creating negative **knowledge capital spillover** (Maghari and Ardekani 2011).

According to Gruère (2006), the EU labelling regulation actually acted like a market ban. His observations in French supermarkets suggest that the strict regulation pushed processors and retailers to remove GM ingredients to avoid the cost of labelling. He further argues that the EU mandatory labelling policy has created negative **network effects** by obliging exporters of food products to follow a strict traceability program when reaching the EU market. This may heavily influence the decisions of developing countries to introduce GM crops.

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1.3.4.4 *Synthesis of EU GMO policies' impacts on social, environmental and economic factors*

Table 9 provides a synthesis of the impacts of EU GMO policies and their instruments on social, environmental and economic externalities, as suggested by the literature review.

Table 9. Synthesis of reviewed positive (+), negative (-), and non-directional (/) impacts of EU GMO policy instruments on social, environmental and economic factors

	Social	Environmental	Economic
Ex-ante risk assessment	(+) (-) Transparency and choice availability (/)	(+) (-) (/) Undissociated	(+) (-) Market structure (-) Employment (-) Costs (-) Knowledge capital spillovers (-) Human capital spillovers (/)
Market & post-market risk management Monitoring and surveillance	(+) (-) (/)	(+) (-) (/)	(+) Knowledge capital spillovers (-) (/)
Market & post-market risk management Traceability & labelling	(+) Freedom of choice (-) Transprency (/)	(+) Undissociated (-) (/)	(+) (-) Compliance costs (-) Knowledge capital spillovers (-) Network effect (/)

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Natural resources and ecosystem management

1.4 Fisheries

1.4.1 Introduction

By depleting fish stocks, Illegal, Unreported and Unregulated (IUU) fishing is considered one of the greatest threats to marine ecosystems, undermining efforts to manage fisheries sustainably (Ovetz 2007; European Court of Auditors 2022). Industrial, unregulated fishing has negative consequences for non-targeted species, such as sea turtles, seabirds, marine mammals and other threatened marine species that are caught, injured and killed by inappropriate fishing practices. Overall, by destroying both predatory and prey species upon which complex ecosystems rely for survival, fishing bycatch has extensive negative consequences on the whole marine biodiversity (Ovetz 2007).

The annual global scale of IUU fishing is estimated at about 11–26 million tons, determining an economic loss of 10–23.5 billion dollars (D'Amico et al. 2016). This represents a significant cost that is not directly borne by the fishers themselves but imposed on the oceans and society (Ovetz 2007). Despite commitments to end illegal fishing by 2020 under the Sustainable Development Goals framework, unsustainable fishing persists worldwide (European Court of Auditors 2022).

Additional environmental externalities of fisheries include contribution to the emissions of climate warming carbon dioxide gases by industrial vessels (Ovetz 2007). Aquaculture also participates in the environmental degradation associated with food production systems. In particular, it has negative environmental impact through wastes offloads, introduction of alien species, genetic interactions, disease transfer, release of chemicals, use of wild recourses, alterations of coastal habitats and disturbance of wildlife (Grigorakis and Rigos 2011).

Beyond the extensive environmental damage caused to the marine ecosystems, unsustainable fishing practices have considerable negative economic and social consequences for coastal communities (Ovetz 2007). Among these hidden costs, Ovetz (2007) cites the damage to small-scale fishing activities – with related employment effect –, threats to local food security, losses to indigenous island cultures and harm to more lucrative sustainable economic activities such as sportfishing, tourism, whale watching and diving.

Social costs are further exacerbated by consumer safety issues associated with aquaculture practices. They include the generation of antibiotic-resistant microorganisms, contaminants transferred to humans though food chain and other hazards from consumption of aquacultured items (Grigorakis and Rigos 2011).

The EU is a major global player in fisheries, both in terms of its fishing fleet and as the world's largest importer of fishery products (European Court of Auditors 2022). As such, its market is at risk of being affected by fisheries products with negative socioeconomic and environmental impacts.

1.4.2 Description of fishery-related policies at EU-level

From net to plate, fishery products can be caught, transshipped, landed, stored, processed, transported and sold along highly complex, globalized supply chains; combating IUU fishing therefore requires a global response (European Court of Auditors 2022). At international level, the United Nations has developed and adopted a range of legally binding instruments, plans of action and voluntary guidelines. At regional level, countries with fishing interests in a given geographical area have organized themselves in Regional Fisheries Management Organizations. The EU is party to all major international instruments and a member of 18 Regional Fisheries Management Organizations and fisheries bodies (European Court of Auditors 2022).

Furthermore, driven by the overexploitation of fish stocks, the increasing complexity of trade flows and the spread of IUU, specific EU policies have been adopted to better manage the fisheries sector (D'Amico et al. 2016). Table 10 provides an overview of these main policies, by chronological order.

Table 10. List of main EU policies enabling the internalization of externalities linked to fisheries in food systems

Policy ID	Title	Topic	Date of entry into force	Date of application	History
Directive 2008/56/EC	Establishing a framework for community action in the field of marine environmental policy	Marine Strategy Framework Directive	Jun 2008	Jul 2010	Directive (EU) 2017/845 amends the MSFD
Regulation (EC) 1005/2008	Establishing a community system to prevent, deter and eliminate illegal, unreported and	Illegal, Unreported and Unregulated fishing	Oct 2008	Jan 2010	Amending Regulations (EEC) No 2847/93, (EC) 1936/2001 and (EC) 601/2004 and repealing Regulations (EC)

	unregulated fishing,				1093/94 and (EC) 1447/1999
Regulation (EC) 1224/2009	Establishing a Union control system for ensuring compliance with the rules of the common fisheries policy	Control	Dec 2009	Jan 2010	Amending Regulations (EC) 847/96, (EC) 2371/2002, (EC) 811/2004, (EC) 768/2005, (EC) 2115/2005, (EC) 2166/2005, (EC) 388/2006, (EC) 509/2007, (EC) 676/2007, (EC) 1098/2007, (EC) 1300/2008, (EC) 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) 1627/94 and (EC) 1966/2006
Regulation (EU) No 1380/2013	On the Common Fisheries Policy	CFP	Dec 2013	Jan 2014	amending Council Regulations (EC) 1954/2003 and (EC) 1224/2009 and repealing Council Regulations (EC) 2371/2002 and (EC) 639/2004 and Council Decision 2004/585/EC

The fisheries policies are currently under review, but at the time of writing they are in force and directly applicable to EU MSs.

1.4.2.1 Directive 2008/56/EC – Marine Strategy Framework Directive

Directive 2008/56/EC establishes a framework for community action in the field of marine environmental policy. It is known as the Marine Strategy Framework Directive (MSFD). The MSFD sets out a common European Union approach and objectives for the prevention, protection and conservation of the marine environment in view of the pressures and impacts of damaging human activities, while allowing for its sustainable use, by means of an ecosystem-based approach (EU Monitor 2008). In particular, the MSFD requires MSs to develop strategies to achieve 'good environmental status' (GES), as well as programmes to implement and monitor the measures to achieve GES.

1.4.2.2 Regulation (EC) 1005/2008 – Illegal, Unreported and Unregulated fishing

The illegal, unreported and unregulated (IUU) fishing regulation is the main EU instrument for preventing, deterring and eliminating such fishing. It requires Member

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States to take action against fishing vessels and EU nationals engaged in illegal fishing activities anywhere in the world (Regulation (EC) 1005/2008 2008). The two most prominent features of this regulation are the catch certification scheme and the carding system (European Court of Auditors 2022). The first aims to ensure the legality of imports and the second identifies 'third countries' (non-EU countries) that are not cooperating in the fight against illegal fishing.

1.4.2.3 Regulation (EC) 1224/2009 – Control

The fisheries control regulation focuses on EU fleet activities, establishing an EU-wide control system for ensuring compliance with the CFP; it applies to all fishing activities in EU waters and all those carried out elsewhere by EU vessels (Regulation (EC) 1224/2009 2009).

To reach the objectives of the CFP, the fisheries control regulation contains provision for MSs and fishery operators including monitoring access to waters and resources; controlling the use of fishing opportunities and capacity; ensuring appropriate enforcement measures in the event of infringements; enabling the traceability and control of fisheries products throughout the supply chain. The control and inspection operations are coordinated by the European Fishery Control Agency (EFCA), which also fosters cooperation among Member States in order to improve the implementation of and compliance with the CFP.

Related policies

For the control of third-country fishing vessels operating in EU waters and EU vessels fishing elsewhere:

- Regulation (EU) 2017/2403 of the European Parliament and of the Council of 12 December 2017 on the sustainable management of external fishing fleets, and repealing Council Regulation (EC) 1006/2008

1.4.2.4 Regulation (EU) No 1380/2013 – CFP

The Common Fisheries Policy (CFP) is the primary framework for fisheries management in the EU (Regulation (EU) No 1380/2013 2013). It is a set of rules aimed at managing sustainably European fishing fleets and conserving fish stocks. Initially embedded within the CAP, the CFP started with the same objectives: increase productivity, stabilize markets, provide healthy food, and ensure reasonable prices for consumers (European Commission n.d.; Wakefield 2018). Over time it has gradually become more independent. From its first outlines in 1970, the policy has undergone regular reforms, with the latest iteration adopted at the end of 2013 and enforced since the start of 2014 (Wakefield 2018). It is in the 2002 reform that sustainability was added as a core objective of the CFP, with the main goal of ensuring the long-term viability of the fisheries sector through sustainable exploitation (Wakefield 2018).

Under this CFP, the EU has the sole authority and responsibility for legislating and adopting binding acts on fisheries management within its Member States. Once agreed, Member States must comply with the terms of the CPF. It adopted, in particular, two main pieces of legislations for combating illegal fishing : the illegal, unreported and unregulated fishing regulation (Regulation (EC) 1005/2008 ; mainly concerning imports) and fisheries control regulation (Regulation (EC) 1224/2009; mainly focusing on compliance by EU fishers) (European Court of Auditors 2022).
The Member States are responsible on their side for implementing key requirements of the common fisheries policy such as inspecting vessels, checking imports and applying sanctions (European Court of Auditors 2022).

Through the CPF, the EU regulates fishing Total Allowable Catches (TACs). These are set for each fish stock annually, or for longer periods, based on scientific advice and management objectives. Each Member State is allocated a pre-determined share of the TACs, known as the relative stability, using a fixed allocation key that is based on historic catches. However, allocations of quotas within the national fishing sector are the responsibility of the individual MS (Nielsen et al. 2019). In that regard, as proposed (but not mandated) by the EC, many MSs have introduced Individual Transferable Quotas (ITQ) management systems.
TACs are addressed each year in specific amending regulations and decisions that take into account the species, fishing region, and the state of the fish stocks.

Related policies
To establish a common market:
- Regulation (EU) No 1379/2013 of the European Parliament and of the Council of 11 December 2013 on the common organisation of the markets in fishery and aquaculture products, amending Council Regulations (EC) 1184/2006 and (EC) 1224/2009 and repealing Council Regulation (EC) 104/2000

To establish a fund through which the EU supports fisheries control:
- Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund and repealing Council Regulations (EC) 2328/2003, (EC) 861/2006, (EC) 1198/2006 and (EC) 791/2007 and Regulation (EU) No 1255/2011 of the European Parliament and of the Council (The EMFF primarily focused on supporting the implementation of the CFP).
- Regulation (EU) 2021/1139 of the European Parliament and of the Council of 7 July 2021 establishing the European Maritime, Fisheries and Aquaculture Fund and amending Regulation (EU) 2017/1004 (The EMFAF expands the scope of the EMFF to include not only fisheries and maritime activities but also aquaculture).

To establish technical measures:

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- Regulation (EU) 2019/1241 of the European Parliament and of the Council of 20 June 2019 on the conservation of fisheries resources and the protection of marine ecosystems through technical measures, amending Council Regulations (EC) 1967/2006, (EC) 1224/2009 and Regulations (EU) No 1380/2013, (EU) 2016/1139, (EU) 2018/973, (EU) 2019/472 and (EU) 2019/1022 of the European Parliament and of the Council, and repealing Council Regulations (EC) 894/97, (EC) 850/98, (EC) 2549/2000, (EC) 254/2002, (EC) 812/2004 and (EC) 2187/2005 (lays down technical measures concerning: (a) the taking and landing of marine biological resources; (b) the operation of fishing gear; and (c) the interaction of fishing activities with marine ecosystems)

For controlling aspects:

- Regulation (EU) 2019/473 of the European Parliament and of the Council of 19 March 2019 on the European Fisheries Control Agency. It repealed Council Regulation (EC) 768/2005 of 26 April 2005 establishing a Community Fisheries Control Agency and amending Regulation (EEC) No 2847/93 establishing a control system applicable to the common fisheries policy.

1.4.3 Main policy instruments and mechanisms for the internalization of externalities at EU-level

The fisheries policies include several instruments aimed at reducing the negative externalities associated with fisheries. These include both market support and regulatory command-and-control (C&C) measures.

Market-based instruments are implemented to influence fishing behavior and promote sustainable practices through economic incentives and subsidies, as well as markets of rights or permits.
Command-and-control intends to restrict the choices facing actors in order to force compliance with more sustainable fishing practices. They include market & post-market risk management measures to ensure that fishing products entering the EU market are aligned with EU's standards (catch certification scheme, controlling and labelling measures) and implementing tools to compile fishers to adopt sustainable fishing practices (landing obligation and technical measures).

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Table 11. List of policy instruments used in the main EU policies regulating fisheries in food systems

Instrument category	Instrument topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
					Socio	Envi
Market support	Fishing quotas	Regulation (EU)1380/2013	Fishing industry	Fisheries		Effect on biodiversity & ecosystem
	Fisheries subsidies	Regulation (EU)1380/2013; Regulation (EU)508/2014 ; Regulation (EU)2021/1139	Fishing industry	Fisheries	Undissociated	Undissociated
C&C Market & post-market risk management	Catch certification scheme (imports)	Regulation (EC)1005/2008	Fishing industry	Fisheries	Transparency	Undissociated
	Controls (EU activities)	Regulation (EC)1224/2009	Fishing industry	Fisheries		Effects on biodiversity & ecosystems
	Labelling	Regulation (EU)1380/2013; Regulation (EU)1379/2013	Fishing industry	Fisheries	Health; Consumer right	Undissociated
C&C Implementing tool	Landing obligations	Regulation (EU)1380/2013	Fishing industry	Fisheries		Effects on biodiversity & ecosystems
	Technical measures (Minimum fish sizes, fishing gear, etc.)	Regulation (EU)1380/2013; Regulation (EU)2019/1241	Fishing industry	Fisheries		Effects on biodiversity & ecosystems

The mention "undissociated" is used to report an impact that is not fully detailed in the literature.

1.4.3.1 Market support – IOE mechanism

1.4.3.1.1 Fishing quotas

Fishing quotas involve the setting of annual Total Allowable Catch (TACs). The TACs are the central instrument of the CFP for achieving stock conservation objectives in the North-East Atlantic (Borges 2021).

TACs represent a use right to the resource, i.e., the right to fish in this case. By transferring ownership of the right to fish to fishers, these actors are motivated to

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conserve and manage sustainably the resource (Le Gallic 2003; Libecap 2009), thereby reducing negative externalities of fisheries.

1.4.3.1.2 Fisheries subsidies

The European Union has been providing subsidies and financial support to the fishery sector through various funds through time. Initially funded by the Financial Instrument for Fisheries Guidance (FIFG), the European fisheries policy was then funded by the European Fisheries Fund (EFF) for 2007-2013, replaced by the European Maritime and Fisheries Fund (EMFF) for 2014-2020, and finally the European Maritime, Fisheries and Aquaculture Fund (EMFAF) for the current period 2021-2027. The EMFAF expands the initial scope of funding to include not only fisheries and maritime activities but also aquaculture.

Overall, these subsidies encourage and support the adoption of sustainable fishing practices to reduce overfishing, improve safety and working conditions for fishermen, and support the socioeconomic development of fishing communities. They do so by supporting investments in more selective fishing gear and techniques that minimize the impact on non-target species and habitats and modernization of the fleet for better compliance with environmental regulations. They also promote innovation, research, and knowledge transfer within the fisheries sector. This facilitates the development and adoption of new technologies, practices, and management approaches that can reduce negative externalities.

To give an order of magnitude, under the current funding package for the period 2021 to 2027, the total allocation for fisheries amounts to close to EUR 6 billion. Of this, EUR 5,3 billion is to be allocated to the management of fisheries, aquaculture, and fishing fleets; the rest going to scientific advice, controls and verifications, market intelligence, maritime surveillance, and security (Blanco, Bares, and Ferasso 2022).

1.4.3.2 Market & post-market risk management – IOE mechanism

1.4.3.2.1 Catch certification scheme

The EU introduced in 2010 the catch certification scheme for fish to deal with the problems of illegal, unregulated and unreported fishing which threatens the sustainability of fisheries. This instrument is a way to ensure traceability of fishing activities, and thus transparency, with the aim of halting the introduction in the EU market of fishing products with negative environmental performances.

1.4.3.2.2 Controls

Control and enforcement measures are essential for ensuring compliance with fishing regulations. These measures can involve monitoring fishing activities through vessel tracking systems, inspections at sea and in ports, penalties for non-compliance, and cooperation among member states for effective enforcement. Through such measures, the regulation promotes accountability and reduces the potential for externalities associated with overfishing, bycatch, or damage to sensitive habitats.

1.4.3.2.3 Labelling

An important component of the EU fisheries policy is the common market organisation regulation (Regulation (EU) No 1379/2013). It sets EU marketing standards for fishery products and consumer information requirements (labelling) to provide consumers with the necessary indications to make an informed choice at the moment of purchase[4]. For example, the label must indicate the commercial designation of the species, the production method, the catch area and the fishing gear. By providing such information, the labels support the selection of safe, healthier and more environmentally sustainable products (Paolacci et al. 2021). Labelling further acts as a tool to prevent frauds and illegal fishing (D'Amico et al. 2016; Esposito and Meloni 2017). A labelling instrument can thus play a key role in encouraging sustainable fisheries operation (Miller and Mariani 2010).

There is however no EU label certifying the sustainability of fishery products (European Court of Auditors 2022; Schebesta 2016).

1.4.3.3 Implementing tools – IOE mechanism

1.4.3.3.1 Landing obligation

Initially, the CFP focused on prescribing measures to control the composition of the landing, i.e., the fishes that are effectively landed by a vessel, rather than the catches, i.e., the fishes caught at sea. As a result, discarding represented a legitimate means for fishers to comply with the regulation by disposing of catch which cannot be legally landed, as well as fish with a low economic value (Condie, Grant, and Catchpole 2013). Discarding has great negative impacts on the environment, however. It increases the mortality of target and non-target species and alters biodiversity and food webs by supplying increased levels of food (discarded dead specimens) to scavenging organisms on the sea floor (Consoli et al. 2017).

In reaction, the 2013 reform of the CFP proposed to reduce these unwanted catches and eliminate discards through an obligation to land all catches. The Landing Obligation essentially modified the quota system from a 'landing' to a 'catch'-base. The LO is only applicable to TAC-regulated species in the Atlantic and to species that have a minimum conservation reference size in the Mediterranean Sea, caught in European waters or by

[4] Seafood labelling is further regulated under regulations (EU) No.1169/2011 on the provision of food information to consumers. This policy is however out of the scope of this present report.

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European fishing vessels (Borges 2021). There are, however, specific exemptions to the obligation to land.

By banning discarding practice, the landing obligation incentivizes the adoption of more selective fishing, thereby reducing negative externalities associated with IUU fishing (Condie, Grant, and Catchpole 2013; Bohman 2019). Indeed, having to retain and land unwanted catches may result in additional costs that lead to a fall in income, generating economic incentives to avoid unwanted catches (Condie, Grant, and Catchpole 2013).

1.4.3.3.2 Technical measures

Technical measures are a set of rules that govern where, when and how fishing can take place, with the goal of ensuring sustainability (Bellido et al. 2020). They are restrictive by nature. These measures can help mitigate the ecosystem impact of fisheries, by improving fishing efficiency, i.e. technology and gear improvements, or by limiting the access of given areas to fisheries (Bellido et al. 2020). These measures thus help reduce bycatch of non-target species and the impact on the ecosystem.

1.4.4 Evaluation of the impact of the policies instruments on the internalization of externalities

Overall, the legal framework adopted by the EU to regulate fishery seems to have two primary objectives: meeting food security objectives (Wakefield 2018) and ensuring that all fishery products sold in the EU are legal (European Court of Auditors 2022). These leave sustainability criteria behind.

In her paper on European protection of fisheries, (Wakefield 2018) notes in particular that, after more than 40 years of CFP, we are still witnessing overfishing, depleted fish stocks, disrupted food chains, ecological damage, and loss of biodiversity. She observes that priority is persistently given to the preferences of the commercial fisheries industry without balancing measures to help reinstate damaged environments or depleted fish resources. As a result, any improvements under the CFP have been from such a low base that they cannot be described as restorative. A reason advanced by the author for the lack of improvement in fisheries is that scientific advice provided to the EU institutions in devising fisheries policy is given insufficient weight, which has severely impeded the achievement of sustainability objectives (Wakefield 2018).

Thus, the instruments used in EU policies are considered insufficiently adapted to deal with the environmental and social externalities of fishing activities.

(Bohman 2019) further highlights the ineffectiveness of a centralized, top-down approach to fisheries management to respond in an adaptive way to regional variations in the EU. He therefore calls for a change in the institutional structures of the fisheries policies to better include stakeholders and have a more decentralized approach.

1.4.4.1 Market regulation – Fishing quotas

As evidenced by Le Gallic in his global evaluation (2003) of governmental implementation of market-based instruments, such as TAC quotas, in fisheries, the move towards such instruments is relatively slow in many countries. He associates with this observation the unsatisfactory performance of the fishing industry in terms of environmental, social and economic outcomes. One obstacle to the use of market-based instruments would consist in the lack of ex-ante information that is necessary to define the Total Allowable Catch level (Le Gallic 2003). The lack of ex-post comprehensive evaluation of the effectiveness of quotas instruments further restricts the use of such market-based instruments.

1.4.4.1.1 Social impact

It is sometimes perceived that the implementation of TACs system is likely to modify the wealth distribution, including through advantaging some participants, usually the most influential ones, over others (Le Gallic 2003; Kane, Ball, and Brehmer 2022), thereby creating **inequities** in the system. Le Gallic (2003) emphasized that such system was likely to push indigenous, traditional and small-scale fishers out of the industry by larger fishing enterprises, squeezing them out of their livelihood. Besides, **transparency** appears to be a controversial issue in the negotiations of TACs (Carpenter et al. 2016).

1.4.4.1.2 Environmental impact

The Total Allowable Catch quotas system seems to have had a limited success in effectively managing fish resources (Kane, Ball, and Brehmer 2022).
Under the TAC, fishers may have an interest to discard unwilling catches in order to maximize the value of the quota (Le Gallic 2003). Despite the shift from landing quota to catching quota operationalized through the Landing Obligation, illegal discarding of unwanted catches is still a valuable option for farmers to maximize their economic profits under the TAC system. This is the result of a lack of control and a lack of economic incentives to reduce discarding, which encourage the pursuit of the degradation of marine **biodiversity and ecosystems**.

Furthermore, TACs have been criticized for being persistently set above scientific advice recommending Maximum Sustainable Yield (MSY), which contributes to the continuous overexploitation of fisheries (Carpenter et al. 2016; Borges 2018). The agreed TACs being the result of a negotiations between MSs and the EC, they are usually influenced by national domestic interests, which are based on perceived short-term socioeconomic impacts to the detriment of long-term sustainability goals.

Recently, with the implementation of the Landing Obligation, TACs have been adjusted upward to compensate for the discarding ban. This has led to an increase in fishing activity, and with it an increase in unwanted catch and discards, precisely in opposition to the LO objectives (Borges 2021).

1.4.4.1.3 Economic impact

As for all management systems, implementing a quota system is associated with higher **cost** for its implementation and operationalization (Le Gallic 2003).

Furthermore, the allocation of quotas might result in the monopolization of ownership in the hand of some actors as a result of market forces (Le Gallic 2003; Kane, Ball, and Brehmer 2022). The quotas system might thus affect **market structure** in an unfair way. As pointed out by (Kane, Ball, and Brehmer 2022), it should be noted that some fisheries experts believe that the concentration of quota shares in the hands of large fishing fleet owners will generate economic **efficiency** gains in the sector.

1.4.4.2 Market regulation – Fishing subsidies

It is of interest to note that the efficiency of European MSs in the use of the funds for the improvement of the fishery sector suffers great regional disparities (Blanco, Bares, and Ferasso 2022). Since efficiency levels seem to correlate to regional characteristics, public policy measures should be articulated in order to take into account this territorial heterogeneity.

1.4.4.2.1 Social and environmental impact

Overall, the establishment of fishing subsidies by governments worldwide is considered to have contributed to obscuring the true costs of large-scale fishing activities (Ovetz 2007; Villasante et al. 2022). Together with the rise of new fishing technologies and a growing demand for fish resources, it has led to a global **depletion of fish stocks** and associated **damage to marine ecosystems** and coastal **communities' livelihoods** (Ovetz 2007; Lam 2012).

1.4.4.2.2 Economic impact

Fishing subsidies are reported to have contributed to fleet overcapacity and the artificial maintenance of the profitability of the fishing industry, thereby distorting the efficient allocation of inputs (Villasante et al. 2022). This effect on the **structure of fishing market** is perceived as socially and economically inefficient and has thus been qualified as harmful (Villasante et al. 2022).

1.4.4.3 Market & post-market risk management – Catch certification scheme (imports)

For imported products, the EU catch certification scheme aims to ensure that flag states certify the legality of all imported fishery products based on their own control and monitoring systems. When comparing with the second (USA) and third (Japan) importers

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of fishery products, the EU tends to have the most comprehensive catch certification schemes in terms of scope, information required, and validation and control processes (European Court of Auditors 2022). Despite this effort, significant differences in scope and quality of checks by Member States is reported to weaken the whole system (European Court of Auditors 2022).

1.4.4.3.1 Social impact

In its 2022 special report on EU action to combat illegal fishing, the European Court of Auditors concluded that the control systems in place to combat illegal fishing are partially effective in reducing the risks of illegal fish on EU market by improving **traceability**. However, their effectiveness is reduced by the uneven application of checks and sanctions by Member States.

Concerns have been raised on the generation of **inequities** resulting from the categorical identification and certification against IUU practices (Song et al. 2020). It is considered by Song *et al.* (2020) as a risk to disregard the diversity, legitimacy and sustainability of small-scale fisheries practices. This could result in the creation of unfair burden on small-scale fisheries and countries who depend on them.

1.4.4.3.2 Environmental impact

While the catch certification scheme is relevant in controlling the legality of imported fishery products, it is unsuitable for **environmental performance** control. Indeed, the scheme cannot ensure that the rules applied in non-EU countries are sufficiently stringent to guarantee sustainability (European Court of Auditors 2022).

1.4.4.3.3 Economic impact

The efficiency of control of the catch certification is reduced by the format of the certification, which is still paper-based, and the lack of coordination among Member States (European Court of Auditors 2022). As a result, higher **costs** might arise due to the slower processing time and administrative burden.

The whole scheme might on the other hand foster positive **network effects** by encouraging changes in third countries where control systems are deficient. This mechanism is covered under the carding system of the illegal, unreported and unregulated fishing regulation. Under this system, countries whom control system is not able to efficiently assess the legality of products exported to the EU receive a yellow or red card. Red listed countries, identified as “non-cooperating”, are banned from the European market. Usually, when a country receives notification of deficiencies, it undertakes the necessary reforms and improvements before a formal warning is sent (European Court of Auditors 2022). The European Court of Auditors has thereby

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evidenced the effectiveness of the carding system in sparkling significant reforms in third countries' national system.
Through that process, the Commission continues to cooperate with countries having insufficient certification schemes and provide technical assistance in order to support the improvement of their national system.

1.4.4.4 Market & post-market risk management – Controls (EU activities)

Member States are responsible for the correct application of the EU fisheries control system by controlling fishing activities within their waters, and those of fishing vessels flying their flag, regardless of location (European Court of Auditors 2022). However, fisheries control and enforcement are rather expensive and difficult to enforce, due to the nature of the fisheries (Bohman 2019). The Commission has identified significant shortcomings in fisheries control systems in some MSs, leading to overfishing and underreporting of catches (European Court of Auditors 2022). In particular, while the majority of serious infringements detected led to sanctions, these varied considerably across MSs for similar infringements, with cases in which sanctions were neither proportionate, nor dissuasive (European Court of Auditors 2022).

1.4.4.4.1 Environmental impact

Similarly to the catch certification, ensuring Member States' compliance with EU rules does not mean that the rules themselves are sufficient to ensure the **sustainability of fish stocks and their habitats** (European Court of Auditors 2022). The European Environment Agency reported in 2019 that the overexploitation of commercial fish and shellfish stocks continues across Europe's seas. Later, the European Court of Auditors emphasized that EU actions to protect the marine environment had resulted in measurable progress in the Atlantic, but that the Mediterranean remained significantly overfished (European Court of Auditors 2022).

1.4.4.4.2 Economic impact

As stated by Bohman (2019), fisheries control and enforcement are typically rather expensive. Implementing such an instrument therefore generates significant **costs** in order to set in place control and surveillance requirements.

To reinforce its control system, the EU invested in fisheries funds providing support to MSs for monitoring, control and enforcement activities. This allowed MSs to invest extensively in control measures, including though the installation and development of control technology, the modernization and purchase of patrol vessels and aircraft, and the development of innovative control techniques (European Court of Auditors 2022). Overall, the implementation of and financial support to the fisheries control system in EU has therefore created **knowledge and infrastructure spillovers**.

1.4.4.5 Market & post-market risk management – Labelling

While labelling is recognized as an important instrument to allow consumers to make an informed purchasing choice, there seems to be a wide disparity in the compliance with labelling requirement among EU MSs (Paolacci et al. 2021). High compliance to labelling in some countries, such as Portugal, was tentatively linked to higher seafood consumption and to a number of other factors, including the level of law enforcement and sociological, as well as cultural factors. Portugal, for instance, has historically a high level of legislative protection of consumers, while the UK on the other hand, where lower labelling compliance was observed, generally displayed a greater political aversion to EU regulation and was subject to several food fraud and quality issues (Paolacci et al. 2021). Differences in regional authorities with varying competences in seafood control might further explain the discrepancies in compliance.

Several studies reported the persistent difficulties of implementation of Regulation (EU) No 1379/2013 on the common market organization and its labelling requirements (D’Amico et al. 2016; Esposito and Meloni 2017; Paolacci et al. 2021). Some called in particular for increased awareness raising among Food Business Operators on the importance of compliance to seafood labelling legislation (Esposito and Meloni 2017).

Failure to comply includes frequent reporting of mislabeling (Miller and Mariani 2010; D’Amico et al. 2016; Esposito and Meloni 2017; Paolacci et al. 2021). This tends to indicate that the EU policies currently in place to regulate seafood labeling have not been adequately implemented and enforced. Additional EU legislative efforts should be redirected to tackle this issue.

Regarding the possibility of an EU Ecolabel, (Schebesta 2016) highlights the need of public regulators to come to terms with the powers of private regulators in that domain. Privates have increasingly taken up the role of standard setters, with for instance retailers drawing up a Code of Conduct or certification scheme owners. In that context, the creation of an EU Ecolabel would be a way of taking back some regulatory power from
private to public regulators, which is not perceived as favorable.

1.4.4.5.1 Social impact

The exclusion of prepared and processed products and aquatic invertebrates from the application of the mandatory seafood labelling provisions was identified as a major shortcoming, **depriving consumers of important information** on product origin (D’Amico et al. 2016). In this regard, the EU should require more transparency and full chain traceability for such products, in order to ensure that all seafood marketed within the Member State are safe, legally caught and honestly labeled.

1.4.4.5.2 Environmental impact

At the environmental level, frequent mislabeling has been identified as a serious drawback to efforts made in order to allow **depleted stock**s to recover (Miller and Mariani 2010).

1.4.4.6 Implementing tool – Landing Obligation

The Landing Obligation, if effectively implemented, can serve as a valuable tool for protecting the marine ecosystem by promoting an ecosystem approach and boosting selective fishing (Bohman 2019; Borges 2021). Strict compliance with the discard ban and the provision of strong incentives for fishers to change their fishing practices are however crucial for achieving this outcome. The European Commission (2020a) however noted that compliance with the landing obligation in general still appears to be low.

Because of the lack of control measures and for economic reasons, discarding practices continue with minimal change (Bohman 2019; Borges 2021). An effective implementation of the landing obligation thus requires stringent control and enforcement, and economic incentives to land more of the catch. As it appears, Member States have not adopted the necessary measures to accommodate with the Landing Obligation and significant undocumented discarding of catches remains widespread (European Commission 2020a; Borges 2021)
Furthermore, (Borges 2021) estimates that the Landing Obligation is being widely circumvented by the significant increase in exemptions that have been adopted. This undermines the purpose of the Landing Obligation of reducing unwanted catch (Borges 2021).

1.4.4.6.1 Environmental impact

(Bellido et al. 2017) identified an increase in the illegal marketing of fish below the minimum size as one possible consequence of the Landing Obligation. Besides, since landing unwanted catches is economically not advantageous, fishers might be tempted to unlawfully discard them (Le Gallic 2003; Bohman 2019). These behaviors, instead of reverting the trend, could actually reinforce the **depletion of fish stocks**.

1.4.4.6.2 Economic impact

To avoid any economic loss associated with the landing of untargeted, undervalued, fish species, the industry is encouraged, through the Landing Obligation, to develop selective fishing gears and practices (Feekings et al. 2019). This could favor **knowledge capital spillovers** in the research and development for adapted fishing technologies. A reported drawback, on the other hand, in the generation of knowledge brought by the Landing Obligation is the rise of false reporting (Bohman 2019). To avoid economic losses associated with the landing of untargeted fish species, fishers could resort to illegal discard, which leads to false reporting of data.

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1.4.4.7 Implementing tool – Technical measures

1.4.4.7.1 Environmental impact

Using the example of sea bass fishery around England and Wales, Pawson, Pickett, and Smith (2005) showed that, when based on extensive consultation with all users of the sea and on sound science, technical measures introduced to better manage the fishing resources can have positive environmental impacts. In their evaluation, the measures helped increase the protection of juvenile fish and helped **safeguard the stock fished**.

However, Wales, Pawson, Pickett, and Smith (2005) also pointed out that examples of similar success due to technical management measures were hard to come by. Dolman et al. (2021) confirmed that current EU measures on fisheries **protection from bycatch**, with a focus on cetaceans, were inadequate in themselves.

1.4.4.7.2 Economic impact

Bellido et al. (2020) highlight that technical measures do not necessarily ensure fishers' economic gains since they imply **costs** for their implementation. However, it has been recognized that the losses generated in the short and medium term by the implementation of technical measures tend to be compensated by **gains** in the long term.

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1.4.4.8 *Synthesis of EU fisheries policies' impacts on social, environmental and economic factors*

Table 12 provides a synthesis of the impacts of EU fishery policies and their instruments on social, environmental and economic externalities, as suggested by the literature review.

Table 12. Synthesis of reviewed positive (+), negative (-), and non-directional (/) impacts of EU fishery policy instruments on social, environmental and economic factors

	Social	Environmental	Economic
Market support Fishing quotas	(+) (-) Equity (-) Transparency (/)	(+) (-) Biodiversity and ecosystems (/)	(+) Efficiency (-) Compliance costs (-) Market structure (/)
Market support Fisheries subsidies	(+) (-) Coastal communities' livelihood (/)	(+) (-) Biodiversity and ecosystems (/)	(+) (-) Market structure (/)
Market & post-market risk management Catch certification scheme	(+) Traceability (-) Equity (/)	(+) Undissociated (-) (/)	(+) Network effect (-) (/)
Market & post-market risk management Controls	(+) (-) (/)	(+) (-) Biodiversity and ecosystems (/)	(+) Knowledge (+) Infrastructure spillover (-) Compliance costs (/)
Market & post-market risk management Labelling	(+) (-) Transparency (/)	(+) (-) Biodiversity and ecosystems (/)	(+) (-) (/)
Implementing tools Landing obligations	(+) (-) (/)	(+) (-) Biodiversity and ecosystems (/)	(+) Knowledge (-) (/)
Implementing tools Technical measures	(+) Biodiversity and ecosystems (-) (/) Biodiversity and ecosystems	(+) (-) (/)	(+) Long-term gains (-) Compliance costs (/)

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2 THE SOCIAL SPHERE

Animal health and welfare

2.1 Animal health and welfare

2.1.1 Introduction

The state of health of farmed animals kept for food, as well as their overall well-being can have significant impact on the economy, but also on indirect elements such as human health. With the specialization and industrialization of modern agriculture, livestock production has intensified through increased herd sizes and stocking densities (Vogeler 2019). These processes have increasingly contributed to challenges related to animal health and welfare.

In terms of direct economic impact, animal diseases might adversely affect farm production through higher mortality, reduced output quality, and higher use of inputs such as medication (Bennett 2012). A direct cost is further associated to the detection, diagnosis, prevention, and control of animal diseases. Besides, the emergence of diseases might generate trade restrictions and affect tourism, which can impact rural economies (Bennett 2012; Vetter, Vasa, and Ózsvári 2014).

In addition to the direct effect on farms and regional economies, both livestock disease and its control have a number of indirect effects on third parties. Bennett (2012) identifies three important negative externalities in the context of livestock disease: impacts on the health of other producers’ livestock, on human health, and on animal welfare. More difficult to identify and calculate, these indirect effects are however significant and lead to additional costs to society, as resources need to be allocated to diseases control.

2.1.2 Description of animal health and welfare-related policies at EU-level

Given that the economic incentives to improve animal welfare are relatively weak, policymakers have responded by adopting specific farm animal welfare regulations (Vogeler 2019). The development of animal health and welfare regulations in the agriculture sector in Europe has been a gradual process that began in the 1970s. Since then, the European Union has introduced numerous measures to improve animal welfare and safeguard public health and the environment. During the 1990s, the occurrence of Bovine Spongiform Encephalopathy (BSE), commonly known as mad cow disease, gave rise to a severe public health and political crisis relating to food safety in Europe. This crisis in particular triggered an important response, with a set of animal

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health and safety measures introduced, and the adoption of a robust precautionary approach to manage the issue (Ferrari 2016; Margalida et al. 2010).

The first concrete legal step aimed at promoting animal welfare dates back to the 1970s with the adoption of Council Directive 74/577/EEC on stunning of animals before slaughter and Council Directive 77/489/EEC of 18 July 1977 on the protection of animals during international transport (Regulation (EC) 1/2005 2018; Vogeler 2019). From the 1980s onwards, specific regulations set minimum standards for the rearing and handling of specific farmed animals (pigs, calves and laying hens first, followed by chickens kept for meat production in 2007) (Vogeler 2019; Vetter, Vasa, and Ózsvári 2014).
In 1993, the Declaration on Animal Welfare was included in the Maastricht Treaty, and in 1997, that declaration became a protocol with legal status. The Treaty of Amsterdam officially recognized animals as sentient beings in 1999, meaning that they can no longer be treated as things, objects or goods (Regulation (EC) 1/2005 2018; Vogeler 2019). The Protocol on Animal Welfare annexed to the Treaty of Amsterdam imposed an obligation on EU institutions and Member States to take account of animal welfare considerations. A decade later, an animal welfare strategy was adopted in 2012 for the period 2012-2015 to improve welfare standards in the EU, with the main purposes of the strategy focused on implementation and enforcement of existing standards, information of all involved actors, and coordination with the common agricultural policy (Regulation (EC) 1/2005 2018). However, to date, the implementation and enforcement of EU animal welfare policies remains a common problem in Member States (Vogeler 2019).

In addition to the development of regulations directly targeted at animal health and welfare, the EU provides financial assistance based on support schemes from the Common Agricultural Policy (CAP). Financial incentives are provided to farmers who take animal-welfare-related measures that go beyond the mandatory standards defined by EU regulations (Vogeler 2019). Nonetheless, out of the total CAP budget, only 1.4% was spent on such measures in the reporting period 2014–2020 and large discrepancies existed between Member States : Germany often goes beyond the EU directives for animal welfare regulations for instance, while in France, regulatory animal welfare policies essentially correspond to the minimum requirements put forward by the European Union (Vogeler 2019).

Today, the animal health and welfare policies of the European Union encompass all facets of farm animal production, starting from the manufacturing and market placing of medicated feed to the animal's life on the farm, during transportation, and at time of slaughter, as well as trade. Table 13 provides an overview of these main policies, by chronological order.

While substantial improvements have been made since the first legal acts on animal health and welfare, such as bringing the very notion of animal welfare into common use and understanding and slowly shifting from simple removal of physical suffering to broader enhancement, many flaws are still associated to EU animal welfare regulations (Buller et al. 2018; Vogeler 2019; European Commission 2020b; Speeckaert 2022). As existing regulations demand mostly minimum standards and do not cover all farmed species, several member states have passed additional national regulations, which has resulted in a large heterogeneity of animal welfare regulations within the European Union (Vogeler 2019).

In their study to support the evaluation of the European Union strategy for the protection and welfare of animals, the Directorate-General for Health and Food Safety recognized that compliance across Member States in some animal welfare legislative areas remains a key challenge. Further, there is increased citizen demand for information on these topics, however, the Union's strategy for animal welfare has failed to improve the provision of adequate information to consumers (European Commission 2020b).

Besides, welfare regulations are still considered to be dominated by the intensive farming systems that are driven by market-based policies (Speeckaert 2022). Increasing recognition of the integrated aspects of human health, animal health, and the environment is, however, contributing to the emergence of a "One Health" approach. As such, more recent regulations such as the Animal Health Law (Regulation (EU) 2016/429) emphasize the importance of collaboration between human health, animal health, and environmental sectors to address public health risks associated with animal diseases and to combat the spread of antimicrobial resistance in both human and animal health sectors.

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Table 13. List of main EU policies enabling the internalization of externalities linked to animal health and welfare in food systems

Policy ID	Title	Topic	Date of entry into force	Date of application	History
Directive 2003/99/EC	On the monitoring of zoonoses and zoonotic agents	Zoonoses - Monitoring	Dec 2003	Apr 2004	Amending Council Decision 90/424/EEC and repealing Council Directive 92/117/EEC
Regulation (EC) 2160/2003	On the control of salmonella and other specified food-borne zoonotic agents	Zoonoses - Salmonella	Dec 2003	Dec 2003	
Regulation (EC) 1/2005	On the protection of animals during transport and related operations	Transport	Jan 2005	Feb 2005	Amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) 1255/97
Regulation (EC) 1069/2009	Laying down health rules as regards animal by-products and derived products not intended for human consumption	Animal by-products	Dec 2009	Dec 2009	Repealing Regulation (EC) No 1774/2002
Regulation (EC) 1375/2015	Laying down specific rules on official controls for Trichinella in meat	Zoonoses - Trichinella	Aug 2015	Sept 2015	
Regulation (EU) 2016/429	On transmissible animal diseases and repealing certain acts in the area of animal health	Zoonoses - Animal Health Law	Mar 2016	Apr 2021	
Regulation (EU) 2017/625	On official controls and other official activities performed to ensure the application of food and feed	Official Controls	Apr 2017	Dec 2019	Amending Regulations (EC)999/2001, (EC)396/2005, (EC)1069/2009, (EC)1107/2009, (EU)1151/2012, (EU)652/2014, (EU)2016/429 and

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	law, rules on animal health and welfare, plant health and plant protection products				(EU)2016/2031 of the European Parliament and of the Council, Council Regulations (EC)1/2005 and (EC)1099/2009 and Council Directives 98/58/EC, 1999/74/EC, 2007/43/EC, 2008/119/EC and 2008/120/EC, and repealing Regulations (EC)854/2004 and (EC)882/2004 of the European Parliament and of the Council, Council Directives 89/608/EEC, 89/662/EEC, 90/425/EEC, 91/496/EEC, 96/23/EC, 96/93/EC and 97/78/EC and Council Decision 92/438/EEC
Regulation (EU) 2019/6	On veterinary medicinal products	Veterinary medicinal products	Jan 2019	Jan 2022	Repealing Directive 2001/82/EC
Regulation (EU) 2019/4	On the manufacture, placing on the market and use of medicated feed	Medicated Feed	Jan 2019	Jan 2022	Amending Regulation (EC)183/2005 of the European Parliament and of the Council and repealing Council Directive 90/167/EEC

2.1.2.1 Policies directly related to foodborne zoonoses

The European Food Safety Authorities defines zoonosis as an infection or disease than can be transmitted directly or indirectly between animals and humans, for instance by consuming contaminated foodstuffs or through contact with infected animals (EFSA 2016). According to Wielinga and Schlundt (2013), the majority of zoonotic disease cases are related to animals bred for food purposes, therefore the need to regulate the implementation of adequate agricultural and handling practices.

To that effect, the EU has developed several instruments aimed to protect animal and public health by preventing, controlling, and eradicating the spread of diseases in animals and food products.

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2.1.2.1.1 Directive 2003/99/EC of the European Parliament and of the Council of 17 November 2003 on the monitoring of zoonoses and zoonotic agents

This regulation aims to ensure a coordinated approach to monitoring and controlling zoonotic diseases in the EU by establishing a consistent framework for the collection, analysis, and dissemination of information on the occurrence and distribution of zoonoses and zoonotic agents, as well as the identification of emerging risks across the European Union (Directive 2003/99/EC 2003).

2.1.2.1.2 Regulation (EC) 2160/2003 on the control of salmonella and other specified food-borne zoonotic agents

The regulation aims to control the spread of salmonella and other food-borne zoonotic agents. It requires Member States to establish national control programs for various zoonotic agents in poultry and other animals, as well as to monitor the occurrence of these agents in food products (Regulation (EC) 2160/2003 2003). The regulation also sets out rules for the identification, investigation, and notification of outbreaks of zoonotic diseases.

2.1.2.1.3 Regulation (EC) 1375/2015 laying down specific rules on official controls for Trichinella in meat

This regulation was adopted in 2015 to ensure the safety of meat products in the EU. It aims in particular to ensure that meat from animals infected with Trichinella is not placed on the market (Implementing Regulation (EU) 2015/1375 2015). The regulation lays down specific rules for the official controls to be carried out by competent authorities to detect the presence of Trichinella in meat. It also sets out rules for the classification and labelling of meat products based on their level of risk for Trichinella, as well as the actions to be taken in case of non-compliance with the regulation.

While Trichinella monitoring is mandatory at abattoir level in all EU countries, Salmonella control plans seem to have been implemented by some countries only, frequently on a voluntary basis (Bonardi et al. 2021). Divergence can be observed between northern and southern EU countries, as the former apply *Salmonella* control programs in pigs for instance, but the latter do not (Bonardi et al. 2021).

2.1.2.1.4 Regulation (EU) 2016/429 of the European Parliament and of the Council of 9 March 2016 on transmissible animal diseases and repealing certain acts in the area of animal health

This regulation, also known as the Animal Health Law (AHL), provides a general framework for the prevention, control, and eradication of transmissible animal diseases. The regulation was adopted in March 2016, and entered into force in April 2021 after a five-year transitional period. The regulation was adopted to establish a single regulatory tool to cover all aspects of animal health, thereby consolidating numerous pieces of legislation relating to animal health and welfare in the EU, while simplifying and harmonizing the rules across Member States (Loria et al. 2022). It sets out a risk-based approach to animal health, focusing on preventing the entry and spread of diseases, and responding effectively to outbreaks. The Animal Health Law places greater emphasis on biosecurity, early detection, and rapid response to animal disease outbreaks (Loria et al. 2022). It also introduces new measures to improve traceability of animals and animal products and sharing of data on the identification and certification of the animals (Loria et al. 2022). Additionally, the regulation strengthens the role of all relevant actors in the management of animal health.

Related policies:

- Commission Implementing Regulation (EU) 2020/2235 of 16 December 2020 laying down rules for the application of Regulations (EU) 2016/429 and (EU) 2017/625 of the European Parliament and of the Council as regards model animal health certificates, model official certificates and model animal health/official certificates, for the entry into the Union and movements within the Union of consignments of certain categories of animals and goods, official certification regarding such certificates.
- Commission Delegated Regulation (EU) 2020/692 of 30 January 2020 supplementing Regulation (EU) 2016/429 of the European Parliament and of the Council as regards rules for entry into the Union, and the movement and handling after entry of consignments of certain animals, germinal products and products of animal origin.

2.1.2.2 Council Regulation (EC) 1/2005 – Transport

The protection of animals during transport is an important aspect of animal welfare. The European Union has a harmonized legal framework for animal transport, designed to provide a level playing field for operators and a sufficient level of protection for the transported animals (Regulation (EC) 1/2005 2018). Animal transport within the EU is regulated by Regulation (EC) 1/2005 that establishes rules for the protection of animals during transport and related operations within the EU. The regulation came into force in January 2005, and applies to all vertebrate animals transported within the EU for economic reasons, including for slaughter, breeding, production, or any other reason. It sets out specific requirements for the handling and transport of animals, including provisions for the design and construction of vehicles used for transport, the provision of food and water, and the duration of journeys. It also requires that transporters have appropriate training and equipment, and that animals be accompanied by documentation that provides information on their origin, destination, and health status.

2.1.2.3 Regulation (EC) 1069/2009 – Animal by-products

Animal by-products have been legally regulated under EU legislation since 2002. The initial Animal by-products Regulation (EU) No. 1774/2002) provided not only rules for by-product categorization, but also for their collection, transport, storage, processing and use. The Regulation was binding until 3 March 2011, when two new legal regulations entered into force: Regulation (EC). 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and Commission Regulation (EU) No. 142/2011 of 25 February 2011 implementing Regulation (EC). 1069/2009 (Jacek, Marta, and Marek 2011).

Regulation (EC) 1069/2009 aims to prevent and minimize risks to public and animal health arising from animal by-products and derived products, and in particular to protect the safety of the food and feed chain (Regulation (EC) 1069/2009 2009). This regulation establishes, among others, harmonized rules for the production and placing on the market of organic fertilizers and soil improvers.

Related policies:

- Commission Regulation (EU) No 142/2011 of 25 February 2011 implementing Regulation (EC) 1069/2009 of the European Parliament and of the Council laying down health rules as regards animal by-products and derived products not intended for human consumption and implementing Council Directive 97/78/EC as regards certain samples and items exempt from veterinary checks at the border under that Directive

2.1.2.4 Regulation (EU) 2017/625 – Official Controls

Regulation (EU) 2017/625, also known as the EU Official Controls Regulation (OCR), entered into force in April 2017. The regulation establishes rules for official controls, inspections, and other activities carried out by EU Member States along the food production chain to ensure compliance with food and feed law, rules on animal health and welfare, plant health, and plant protection products. The main aim of the regulation is to strengthen the EU's system of official controls and to ensure that they are carried out in an efficient, consistent, transparent and coordinated manner across the entire Union (Regulation 2017/625 n.d.). This includes controls on food and feed businesses, from primary producers to retailers and caterers, but also plant/animal breeders, growers and traders.

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Related policies:

- Commission Implementing Regulation (EU) 2020/2235 of 16 December 2020 laying down rules for the application of Regulations (EU) 2016/429 and (EU) 2017/625 of the European Parliament and of the Council as regards model animal health certificates, model official certificates and model animal health/official certificates, for the entry into the Union and movements within the Union of consignments of certain categories of animals and goods, official certification regarding such certificates.

2.1.2.5 Policies related to animal medicines

For the past two decades, concerns regarding antimicrobial use in farm animals grew considerably due to the growing prevalence of antimicrobial resistance (AMR) and the way this affects human health. In the European Union, this political will to contain AMR has led to a European strengthening of the response to AMR with the development of a EU One Health action plan against AMR and the adoption of the animal medicines package including two new regulations on veterinary medicines (Regulation (EU) 2019/6) and medicated feed (Regulation (EU) 2019/4) (EU Monitor 2018; Baudoin, Hogeveen, and Wauters 2021; Simjee and Ippolito 2022). These provide in particular for a wide range of measures to fight antimicrobial resistance and promote a more prudent and responsible use of antibiotics in animals, and are designed to support the Farm to Fork objective of reduction by 50% of the overall EU sales of antibiotics for farmed animals and in aquaculture by 2030 (Simjee and Ippolito 2022).

2.1.2.5.1 Regulation (EU) 2019/6 - Veterinary medicinal products

Regulation 2019/6, commonly known as the New Veterinary Regulation, governs the manufacture, distribution, and use of veterinary medicinal products (VMPs) in the European Union. The regulation entered into force in January 2019 and applies in all EU Member States in January 2022. It repeals Directive 2001/82/EC.

The aim of this legislation is to ensure that VMPs are safe, effective, and of high quality, and that they are used appropriately to protect animal health and welfare, public health, and the environment. In particular, the regulation sets out the requirements for the authorization, registration, and marketing of VMPs, as well as the responsibilities of manufacturers, importers, and distributors. It also includes provisions for the surveillance and monitoring of VMPs once they are on the market, as well as measures to prevent and control the spread of antimicrobial resistance. In addition, the regulation aims to increase transparency and facilitate access to information for stakeholders, including veterinarians, farmers, and the general public.

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2.1.2.5.2 Regulation (EU) 2019/4 - Medicated Feed

EU Regulation 2019/4 on medicated feed, on the other hand, sets out rules on the manufacture, placing on the market, and use of medicated feed for food-producing animals in the European Union. It applies in all EU Member States on January 2022 and repeals Council Directive 90/167/EEC. The regulation aims to ensure the safety and effectiveness of medicated feed, to protect public health and animal health and welfare, and to ensure the proper functioning of the internal market.

2.1.3 Main policy instruments and mechanisms for the internalization of externalities at EU-level

Tableau 14 provides an overview of the main policy instruments that have been implemented to address a failure in providing an optimal allocation of resources to maximize animal health and welfare in agriculture.

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Tableau 14. List of policy instruments used in the main EU policies regulating animal health and welfare in food systems

Instrument category	Instrument topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
					Socio	Envi
C&C Ex-ante risk assessment	Approval processes for animal by-products and medication	Regulations (EC) 1069/2009, (EU) 2019/4	Farmers; Agro-industry;	Consumers	Animal health; Food safety	Toxicity
C&C Market & post-market risk management	Placing on the market and use of animal by-products	Regulation (EC)1069/2009	Farmers; Agro-industry;	Consumers	Food safety	
	Manufacture, storage, transport, placing on the market, prescription and use and disposal of medicated feed	Regulation (EU)2019/4	Farmers; Agro-industry;	Consumers	Animal health; Food safety	Toxicity
	Marketing authorization, supply, use and disposal of veterinary medicinal products	Regulation (EU) 2019/6	Agro-industry;	Consumers	Animal health; Food safety	Toxicity
	Traceability and labelling	Regulations (EC) 1069/2009, (EU) 2019/4, (EU) 2019/6	Farmers; Agri-food industry; Public authorities	Consumers	Consumer rights; Food safety	
	Controls and surveillance	Regulations (EU) 2016/429, (EU) 1375/2015, (EC) 2160/2003, (EC) 1/2005, (EU) 2019/6, (EU) 2017/625, Directive 2003/99/EC	Public authorities Agri-food industry	Consumers	Animal health; Food safety	Toxicity
C&C Implementing tools	Transport of live animal	Regulation (EC)1/2005	Farmers; Agri-food industry	Animals	Animal health	

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2.1.4 Evaluation of the impact of the policies instruments on the internalization of externalities

Over time, policies regarding animal health and welfare have developed and transformed in response to the various externalities arising from intensive livestock systems. Environmental and public health pressures aroused from the increase in manure waste, zoonotic diseases, water and soil pollution and greenhouse gas emissions, while additional health issues are associated to antimicrobial resistance (Speeckaert 2022). Increasingly tight regulations on animal health and welfare in the EU have resulted in substantial progress in most productivity factors. Allowing species to live according to their nature and reducing stress is indeed associated to improved processing of fodder, production of milk and eggs, weight gain and reproductive indicators (Vetter, Vasa, and Ózsvári 2014). For instance, the average cow's milk yield is reported to have increased by 20% between 2000 and 2010 across the EU (Vetter, Vasa, and Ózsvári 2014).

However, official studies to support the evaluation of EU animal welfare policies agree that, while progress has been made through increased regulation, the initial objectives still remain highly relevant today (European Commission 2020b; Regulation (EC) 1/2005 2018). Implementation deficits, such as slow or uneven transposition across and within European countries have been noticed for a number of animal welfare regulations (Regulation (EC) 1/2005 2018; Baudoin, Hogeveen, and Wauters 2021; Mateo-Tomás et al. 2022), thereby hindering the potential of these legislations to reduce the externalities of the food systems linked to animal health and welfare.

Finally, it is worth noting that, following a growing involvement of the private sector in the field of farm animal welfare, public policies seem to progressively shift from regulatory to voluntary approaches. This is supported by a study on private and public action for animal welfare in France and Germany by Vogeler (2019), which concluded that private actors are increasingly engaging in farm animal welfare whilst governmental actors are more and more acting with restraint. Retailers in particular are setting their own animal welfare standards by introducing animal welfare labels, thereby obligating farmers to provide animal welfare standards that go beyond legal requirements.

2.1.4.1 Ex-ante risk assessment

Assessing risks associated with the use of animal by-products and veterinary medicines before their approval into the EU enables policymakers to ensure compliance with high socioenvironmental standards. During this process, prohibitions and restrictions are identified. For instance, Regulation (EC) 1069/2009 on animal by-products prohibits the feeding of terrestrial animals and farmed fish of a given species with processed animal protein derived from the bodies or parts of bodies of animals of the same species. It goes on to prohibit, for farmed animals, the feeding with catering waste or feed material containing or derived from catering waste, or the feeding with herbage from land to which organic fertilizers or soil improvers, other than manure, have been applied unless specific conditions (Regulation (EC) 1069/2009 2009). On veterinary medicines, a ban was established in the EU in the late 1990s on growth-promoting antibiotics.

2.1.4.1.1 Social impact

This ex-ante assessment of risks can however lead to measures that are not always fully adapted to the complexity of the system. For instance, the prohibition on growth-promoting antibiotics was then recognized to have had negative social impact in terms of **increased antibiotics resistance**, with associated human health hazard in relation to resistance in salmonellae, campylobacters and zoonotic strains of E. coli. (Casewell et al. 2003). Indeed, the banned growth-promoting antibiotics were actually accompanied by other, previously unrecognized, health promotional or prophylactic effects. Banning these products thus resulted in a deterioration in animal health, including increased diarrhea, weight loss and mortality. Furthermore, it led to the increased usage of therapeutic antibiotics in food animals, which are identical to those used in human medicine. Casewell et al. (2003) therefore argued that policy bans needed to be carefully weighed against the increasingly apparent adverse consequences.

2.1.4.2 Market & post-market risk management

Various regulations are aimed at managing risks related to animal products, by-products and veterinary medicines when introduced onto the EU market or used by agrifood actors. These regulations mandate, on the one hand, the rules to be followed when manufacturing, placing on the market or using such products, and, on the other hand, the control mechanisms to set in place for the management of zoonoses, transport of live animals, and medication. Such controls and surveillances are useful tools to ensure food safety to consumers and to provide evidence for informed decisions on interventions.

2.1.4.2.1 Environmental impact

Some of these regulations are reported to have impacted the environment. For instance, the implementation of Regulation (EC) 1069/2009 laying down health rules as regards animal by-products and derived products not intended for human consumption, and its implementing regulation (EC) 142/2011, have been outlined as a significant achievement for **biodiversity**, and in particular for scavenger conservation in Europe (Margalida et al. 2010; Morales-Reyes et al. 2015; Mateo-Tomás et al. 2022). By allowing farmers to abandon extensive livestock carcasses in the field, these pieces of legislation help guarantee food supply from livestock carcasses to wildlife. Nonetheless, slow or uneven implementation is a major issue with strong potential to compromise the effective achievement of the regulations' objectives, i.e., reconciling biodiversity conservation (through food provisioning for scavengers) and **public health** (by minimizing the presence of unconsumed carcasses in the field) (Morales-Reyes et al. 2015; Mateo-Tomás et al. 2022). The regulations favoring leaving carcasses in situ for wildlife should also reduce the **GHG emissions** linked to carcass transport and the **costs** associated with that removal, but low compliance prevents that effect (Morales-Reyes et al. 2015).

2.1.4.2.2 Social impact

Regulatory legislations on antimicrobial issues, such as Regulation (EU) 2019/4 on Medicated Feed and Regulation (EU) 2019/6 on Veterinary Medicinal Products, have significantly contributed to **public health** by achieving better antimicrobial use in European livestock production (Simjee and Ippolito 2022; Baudoin, Hogeveen, and Wauters 2021). This is supported by official figures which show a 32,5% decrease in sales of veterinary antimicrobial medicinal products between 2011 and 2017 (Baudoin, Hogeveen, and Wauters 2021).

Animal disease control measures, altogether, are generally considered as effective in controlling and preventing zoonotic diseases (EFSA Panel on Animal Health and Welfare (AHAW) et al. 2021). The introduction of official regulations regarding the obligation to test the meat for specific zoonotic agents is reported to have led to the increasingly rare finding of these zoonotic agents in farmed animals, such as with Trichinella in pig production (Bilska-Zając et al. 2021, 2012–202). This effect is directly associated to improved **public health** thanks to the reduced occurrence of trichinellosis in humans due to the consumption of infected meat.

However, inefficient application of control and surveillance requirements by farmers can lead to continued infection and, thus, to **animal health and welfare** impact, financial **cost** (linked to reduced production quantity and quality, and disease management), as well as social impact due to the **emotional stress** for farmers when dealing with the infections (Crawford et al. 2022). In the study on sheep in Northern Ireland by Crawford et al. (2022), the authors link the inefficiency observed in sheep scab control to knowledge gaps, inadequate resources, poor treatment decisions, under-reporting and low levels of testing. Similarly, inefficient clinical surveillance and risk-based screening of herds is reported by Cárdenas et al. (2019) for early warning in case of bovine brucellosis. While control and surveillance regulation have resulted in large brucellosis-free zones throughout European countries, some countries of Southern Europe remain infected. Possible reasons for the difficulties of bovine brucellosis eradication in this region include, as reported by Cárdenas et al. (2019), the lack of stability of eradication policies, lack of epidemiological data, difficulties of disease eradication in rural areas, lack of laboratory capabilities.

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2.1.4.2.3 Economic impact

In addition to the impact on public health, legislation on antimicrobial issues can lead to a reduction in **production costs** on farms (Baudoin, Hogeveen, and Wauters 2021). However, large variations in antimicrobial use trends and in monitoring efforts at farm level have been observed between European countries. This complicates the evaluation of the impact of these regulations on food system externalities at European level.

Nonetheless, stricter regulations of animal health and welfare can be considered globally a burdensome onus for the food industry, imposing important economic **costs** on it (Ferrari 2016; Vetter, Vasa, and Ózsvári 2014; Frisk et al. 2018). The requirements imposed on farmers and operators in the food sector imply the need to reorganize their structures and adopt new precautions, which involve economic costs that do not bring them direct benefits. The study by Fraser et al. (2010) on poultry and pig farmers in the UK shows that their willingness to adopt is inversely related to estimated cost and this is likely to militate against voluntary adoption of measures to control food-borne zoonoses on farms. They go on to mention that if such changes are to be implemented then they are likely to require subsidies or penalties to farmers to facilitate voluntary adoption. Overall, as reported by Vetter, Vasa, and Ózsvári (2014), EU animal welfare policy must be more market-oriented. It is crucial that producers recover their extra costs and that consumers be aware of their responsibility and are willing to pay for food produced in line with the European model.

Regulations on animal welfare is also affecting the **market structure**, as well as **knowledge** and **infrastructure spillovers**. The operators that have failed to comply with the requirements or did not even want to implement them must eventually shut down their activity. Extra costs to comply with the requirements may also cause some operators to go bankrupt. This means a larger market share for competitors that comply with the requirements (Vetter, Vasa, and Ózsvári 2014). Furthermore, the measures and changes taken to fulfil the animal welfare requirements are often accompanied by technological improvements and modernization (Vetter, Vasa, and Ózsvári 2014).

2.1.4.3 Implementing tools

The EU has mandated specific measures to be implemented in order to improve animal health and welfare. For instance, Regulation (EC) 1/2005 on the Protection of Animals During Transport sets out specific requirements for the handling and transport of animals, including provisions for the design and construction of vehicles used for transport, the provision of food and water, and the duration of journeys. However, and as previously highlighted, uneven transposition across MSs results in large discrepancies in the observed outcomes of such regulations. This renders an EU-wide evaluation of these regulations quite challenging.

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While slight improvement in **animal welfare** has been observed following the minimizing of pick-up stops and transportation time, big differences remain between Member States as regards the progress made in implementation (Frisk et al. 2018). This has consequences for both **animal welfare** and **competitiveness** of the industry due to uneven playing field for operators (Regulation (EC) 1/2005 2018). Furthermore, it was reported **costs** for transport companies increased after the introduction of the regulation.

2.1.4.4 Synthesis of EU animal health and welfare policies' impacts on social, environmental and economic factors

Table 15 provides a synthesis of the impacts of EU animal health and welfare policies and their instruments on social, environmental and economic externalities, as suggested by the literature review.

Table 15. Synthesis of reviewed positive (+), negative (-), and non-directional (/) impacts of EU animal health and welfare policy instruments on social, environmental and economic factors

	Social	Environmental	Economic
Ex-ante risk assessment	(+) (-) Antibiotics resistance (/)	(+) (-) (/)	(+) (-) (/)
Market & post-market risk management	(+) Public health (-) Emotional stress (/) Animal health and welfare	(+) Biodiversity (-) (/) GHG emissions	(+) Production costs; (+) Knowledge capital spillovers; (+) Infrastructure spillovers (-) Compliance costs (/) Market structure
Implementing tools	(+) Animal health and welfare (-) Animal health and welfare (/)	(+) (-) (/)	(+) (-) Competitiveness; (-) Compliance costs (/)

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3 THE ECONOMIC SPHERE

Support to the agricultural sector

3.1 Income support and incentives to farmers

3.1.1 Introduction

The EU farming system is undergoing various challenges, as for a continuous changing of policy context, the influence of climate change and high volatility of world farming prices (Reidsma et al., 2020). Other profound societal changes such as technological advancements, globalization, and evolving consumer preferences are also modifying the environment in which the EU farming system is developing. Its resilience in delivering private and public goods has been therefore challenged and its stakeholders are facing the consequences, with high levels of heterogeneity amongst regions.

The Common Agricultural Policy (CAP) is the primary regulatory framework for the agricultural activities in the EU. Through various mechanisms such as direct payments, rural development initiatives, and market measures, the CAP seeks to balance the interests of farmers, consumers, and the environment. It aims to strike a delicate equilibrium between fostering agricultural productivity, addressing environmental concerns, and supporting the socio-economic well-being of rural communities. The CAP's evolution over time reflects the EU's commitment to adapting to changing agricultural needs, embracing sustainable practices, and responding to emerging challenges in the farming sector.

The CAP is composed of two principal forms of budgetary expenditure – market support, known as **Pillar One**, and a range of selective payments for rural development measures known as **Pillar Two** (Gay, 2005). Each pillar is regulated by a separate legislative framework, that sets the ground for the budgetary administration, the mandatory requirements and various other guidelines to be implemented at MS level. Across the years, the CAP has experienced a shifting of objectives, and the introduction of new regulations or the amendment of already existing ones, following the development of the societal concerns undergoing those objectives.
If in the early years (1957-1992) the focus was on market interventions and price support to ensure food security and stabilize agricultural markets, but in 1992, the MacSharry Reform marked a turning point. It introduced direct payments to decouple support from production. Such turning point was further enhanced by the 2003 Fischler Reform, aimed at responding to the WTO pressures concerning the coupled subsidies and the unfair competitive advantage of the EU agricultural production (Ciaian, Kancs, and

Paloma 2015). In 2013, the CAP reform introduced the Basic Payment Scheme (BPS), aiming at simplifying direct payments and emphasizing greening.

In parallel, Pillar two emerged in 1999 under the Agenda 2000 reform. The "Health Check" reform in 2005 introduced new measures like agri-environmental schemes and support for organic farming. Finally, the 2013 reform merged various rural development programs, prioritizing strategic programming, innovation, and sustainability.

The evolution of the CAP reflects a broader recognition of the need to balance agricultural productivity with environmental protection, rural development, and social considerations.

3.1.2 Description of the income support and incentives to farmers policies at EU-level

The legislative framework of the Common Agricultural Policy (CAP) encompasses a series of regulations that set out the overarching principles and objectives of the policy. These regulations provide the legal framework for the CAP's implementation and define the general rules and obligations for MS.

For the purpose of the evaluation, we have included the three regulations that are at the basis of the CAP multiannual programming period 2014-2020, even though a more recent one covering the period 2023-2027 is already available. This choice was made to conduct a robust coherent and up-to-date evaluation, as the programming period has been highly mentioned in literature, both academic and mixed one.

Concerning previous regulation periods, the framework 2014-2020 was developed under the Better Regulation (EC, 2021), therefore includes ‘lesson from the past’ through its evidence-based decision-making, stakeholder consultations and the use of evaluation methodologies to enhance the transparency, accountability, and effectiveness of regulatory measures.

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Table 16. List of main EU policies related to the CAP

Policy ID	Title	Topic	Date of entry into force	Date of application	History
Regulation (EU) No 1308/2013	Establishing common organisation of the markets in agricultural products	Single CMO Regulation	December 1, 2013	January 1, 2014	Repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007
Regulation (EU) No 1305/2013	Support for rural development by the European Agricultural Fund for Rural Development (EAFRD)	EU Rural Development	December 17, 2013	January 1, 2014	Repealing Council Regulation (EC) No 1698/2005
Regulation EU) No 1307/2013	Establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy	Direct payments	December 20, 2013	January 1, 2015	Repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009

3.1.2.1 Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products

Regulation (EU) No 1308/2013, also known as the "Single CMO Regulation," focuses on the common organization of agricultural markets and covers various sectors such as cereals, sugar, milk and dairy products, wine, fruits and vegetables, and olive oil. The regulation establishes a range of measures to support and manage these agricultural markets. It includes market support programs, market intervention mechanisms, market transparency requirements, quality and labelling standards and various types of support to specific sectors. Overall, the regulation aims to strike a balance between the interests

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of agricultural producers and consumers while promoting a sustainable and competitive agricultural sector. It seeks to stabilize agricultural markets, provide a safety net for farmers, ensure a fair income for producers, and ensure the availability of quality products for consumers.

3.1.2.2 Regulation (EU) No 1305/2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD)

Regulation (EU) No 1305/2013 is a key legislation that governs the support for rural development provided through the European Agricultural Fund for Rural Development (EAFRD). The regulation outlines the objectives, principles, and measures for promoting rural development across the European Union.

The regulation aims to promote sustainable development, enhance the competitiveness of rural areas, and support the implementation of the Common Agricultural Policy (CAP). The regulation encompasses a wide range of measures.
Firstly, there are support schemes for investments in agricultural holdings, which aim to modernize and improve the competitiveness of farms. These schemes cover areas such as farm infrastructure, machinery, and equipment, as well as the diversification of agricultural activities.
Secondly, the regulation includes measures to support Agri-environment-climate initiatives, aiming to preserve and enhance the natural environment. These initiatives promote and incentivize environmentally friendly farming practices, biodiversity conservation, organic farming, and the sustainable management of natural resources.
Furthermore, the regulation supports forestry-related measures, including afforestation, forest management, and investments in forestry technologies.
The regulation also includes measures to encourage cooperation among farmers, facilitating the establishment of producer groups and operational groups. These groups promote collaboration, knowledge exchange, and innovation in agricultural and rural development.
The regulation provides the support for rural business development and diversification, financing initiatives aiming at stimulating economic growth, creating employment opportunities, and enhancing the quality of life in rural areas.

The regulation encourages Member States to develop comprehensive rural development strategies aligned with EU objectives and tailored to the specific needs and potentials of their regions.

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3.1.2.3 Regulation EU) No 1307/2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy

The policy instruments under Regulation (EU) No 1307/2013 govern direct payments to farmers within the Common Agricultural Policy (CAP) framework. The general aim is to provide income support to farmers, encourage sustainable agricultural practices, and promote the efficient use of resources.

The main instrument is the Basic Payment Scheme (BPS), which calculates payments based on eligible hectares, historical references, and regional rules. This scheme is complemented by redistributive payments, targeting smaller and medium-sized farms to ensure fairer distribution of support. The regulation also includes provisions for young farmers, offering additional support to facilitate their entry into the agricultural sector. The regulation relies on cross-compliance requirements, which ensure that farmers adhere to environmental, public health, animal welfare, and food safety standards. Non-compliance with these requirements may result in the reduction or withdrawal of direct payments. Additionally, the regulation promotes the implementation of agri-environmental and climate measures, encouraging farmers to adopt sustainable farming practices and contribute to environmental protection. To ensure proper administration and control, the regulation establishes a system for integrated administration, including the use of satellite imagery and on-the-spot checks. This allows for accurate verification of eligibility and compliance.

3.1.3 Main policy instruments and mechanisms for the internalization of externalities at EU-level

While the legislative framework provides the overall structure and guidance for the CAP, the policy instruments are the practical tools used to implement and operationalize the policy goals on the ground. These instruments can vary across different legislative frameworks within the CAP, as they are designed to address specific challenges and priorities.

However, there are also policy instruments that are common to different legislative frameworks as they are financed under various regulations governing the CAP. We have identified three main type of policy instrument i) **the income support and subsidies schemes**, ii) **the voluntary schemes and financial incentives** and iii) **market support schemes**. If the first category of policy instruments is designed to provide income support and stabilize agricultural market, the second focuses on rural development and includes a range of financial incentives and support measures, varying from sustainable farming practices, environmental stewardship, and diversification of rural economies.

The third aims at stabilizing market, balancing dynamics across the value chain and overall guarantee a balanced level of agricultural productivity.

Table 17. List of policy instruments used in the CAP

Instrument	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
				Eco	Envi
Income support & subsidies	Regulation (EU) 1307/2013	Farmers	Farmers & Society at large	Farmers living standards	Climate change Biodiversity loss Soil destruction
Voluntary schemes & financial incentives	Regulation (EU) 1305/2013	Farmers	Society at large	Rural development challenges	Climate change Biodiversity loss Soil destruction
Market support schemes	Regulation (EU) 1308/2013	Farmers & Agro-industry	Society at large	Market stability and price volatility	

3.1.3.1 Income support & subsidies

Income support to farmers started, in the form we know them now, under the Mac Sharry reforms. These reforms brought about a partial shift from market price support linked to specific quantity of production based on specific quantities (e.g. tones, liters) to direct payments per hectare or animal, introducing what is known as coupled payments (Dries et al., 2019). Such shift was further developed under the reform in 2003, in response to pressure from the World Trade Organization (WTO) concerning unfair advantages provided to the EU's agricultural sector (i.e. price support role in maintaining EU agricultural commodity prices above global prices). This reform progressively decoupled payments from production and introduced decoupled payments, which have become the largest component of the CAP budget (Ciaian, Kancs, and Paloma 2015).

Under the CAP programming period 2014-2020, there are therefore two main types of income support: i) Basic Payment Schemes and ii) Decouple Direct Payments. The first one provides direct income support to farmers based on the eligible hectares of agricultural land they own or manage. The payment amount is determined by factors such as historical reference amounts, entitlements, and land use. The second one allows Member States to provide additional targeted support to specific sectors or regions

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facing specific challenges. It can be coupled to specific agricultural activities, such as livestock production or certain crops.

The CAP provides another series of **subsidy schemes**, targeting specific actors of the farming systems or aiming for some transition towards a more sustainable EU farming system. Such schemes are defined and supported according to the priorities defined under the programming period. For the CAP programming period 2014-2020, the following schemes were provided to MS to implement at their territorial level (First Pillar of the Common Agricultural Policy (CAP), 2022):

Support to target actors:

- *Young farmers scheme* (mandatory for Member States): in order to promote the entrance of young farmers into the agricultural sector and ensure generational renewal, a specific provision is in place to support them. Young farmers, defined as newcomers under the age of 40 who have established their farming operations within the past five years, receive an additional 25% increase in the basic payment for the initial five years. This supplement is financed through a 2% allocation from the national budget, and all Member States are obligated to implement this measure.
- *Small farmers scheme* (voluntary for Member States): this scheme allows for an annual payment of up to EUR 1,250 to be made to small farmers, regardless of their farm size. Participants in this scheme benefit from reduced cross-compliance requirements and are exempt from meeting the greening requirements (see next section for the above-mentioned measures). The implementation of the small farmers' scheme is subject to a maximum cost of 10% of the national funding allocation, unless Member States choose to guarantee that small farmers receive the same level of payment they would have received without the scheme.

Pursuing environmental objectives:

- *Greening*: (mandatory for Member States, mandatory for farmers): farms will be eligible to receive an extra payment per hectare for adopting climate and environment-friendly farming practices. Member States are required to allocate 30% of their national funding towards this greening payment. The greening measures encompass three main aspects: i) crop diversification, ii) preservation of existing permanent grassland, and iii) maintenance of an 'ecological focus area'. To avoid placing undue burden on farmers who are already implementing environmental and sustainability practices, the regulation introduces a 'greening equivalency' system. This system acknowledges that farmers who have already adopted environmentally beneficial practices are considered to have met the basic greening requirements.

- *Cross-compliance* (mandatory for Member States, mandatory for farmers): the provision of cross-compliance requirements was simplified, linking direct payments to farmers' compliance with Member State standards on environmental and agronomic conditions, including soil conservation and maintenance. Additionally, adherence to EU regulations on public health, animal health, environment, and animal welfare is required. Failure to meet cross-compliance rules may result in the reduction or cessation of direct payments.

3.1.3.2 Voluntary schemes & financial incentives

The CAP programming period 2014-2020 has also developed a series of tools to target actions towards a more sustainable EU agri-food system, aiming for environmental and social goals. On this, the second pillar focuses on rural development and includes various voluntary schemes and financial incentives aimed at achieving some specific objectives. These objectives encompass a broad range of areas, including environmental sustainability, climate change mitigation and adaptation, support for agri-food quality schemes, farm modernization and restructuring, and fostering the diversification of rural economies.

The *Agricultural Environmental and Climate Measures* (AECM) represent the biggest **voluntary scheme** under the second pillar of the CAP. The primary purpose of the AECM is to incentivize farmers to adopt practices that enhance environmental protection, biodiversity, and climate resilience. There are various types of AECM available to farmers, including agri-environmental schemes, climate-smart farming practices, and investments in renewable energy and energy efficiency. Participation in AECM is voluntary, and requires a commitment under a multi-year program, often spanning five years. Participating in AECM requires farmers to adhere to certain obligations and requirements as outlined by their respective Member State. These can include adopting specific farming practices, such as crop diversification, wildlife habitat creation, or soil conservation techniques. Farmers may need to allocate specific areas of their land for environmental purposes or follow guidelines related to pesticide and fertilizer use. Compliance with these obligations is essential to continue receiving the financial support and incentives associated with AECM.

The CAP provides other **financial incentives**, targeting rural development issues such as supporting agri-food quality production at local and regional level, and investing in farm modernization and restructuring. Through the support for *Agri-Food Quality Schemes* it promotes and protect high-quality agricultural products with specific characteristics linked to geographical origin (Geographical Indications), traditional production methods (Traditional Specialties Guaranteed), or organic farming practices (Organic Farming). It aims to enhance the value and market recognition of these products, while ensuring consumer trust and supporting rural economies. The support includes financial assistance for obtaining quality certifications, implementing quality control measures, carrying out promotional activities, and improving product marketing. Through this instrument, farmers and producer groups are encouraged to adopt sustainable production methods, preserve traditional know-how, and maintain the authenticity and unique qualities of their agricultural products.

EU farmers have access to *Farm Modernization and Restructuring Incentives*, aiming at supporting farmers in modernizing their agricultural practices and restructuring their farms to improve competitiveness, productivity, and sustainability. These incentives provide financial assistance for investments in new technologies, equipment, infrastructure, and farm restructuring projects. Examples of eligible activities include the adoption of precision farming techniques, investment in renewable energy systems, construction of modernized farm buildings, and the diversification of farm activities. Financial support is typically provided as grants or subsidized loans, and the eligibility criteria and application process vary between Member States.

3.1.3.3 Market support schemes

Along with direct income support and rural development voluntary schemes, market support schemes have been a key component of the CAP programming period 2014-2020, aiming mainly at stabilizing markets, but also ensuring a fair standard of living for farmers, and increase agricultural productivity. These schemes fall mainly under the Common organization of the markets (CMO) Regulation (EU) No 1308/2013. They are applied to a restricted list of products and, after the reform of 2003, the intervention tools under this type of policy instrument were changed considerably, and they are now regarded as ‘safety nets’, i.e. they are used only in the event of crises linked to serious market disruption.

The funding available should account for approximately 4 % (EUR 17.5 billion) of the total CAP budget, and is managed by the European Agricultural Guarantee Fund (EAGF). In 2019, market intervention measures were around EUR 3.4 billion, i.e. 5.5 % of total EAGF expenditure. They can be grouped in four main categories and Table 18 shows the funding share for the period 2014-2019.

Table 18. EAGF expenditure on agricultural market intervention (EUR million – current prices)

	2014	2015	2016	2017	2018	2019
Storage	5.1	18.4	52.4	27.6	182.3	3.0
Export refunds	4.5	0.3	0.6	0.0	0.2	1.1
Other market measures	2 579.6	2 698.0	3 185.2	3 061.1	2 544.6	2 427.8
Total	2 589.2	2 716.7	3 238.2	3 088.7	2 727.1	3 431.9

3.1.4 Evaluation of the impact of the policies instruments on the internalization of externalities

3.1.4.1 Income support and subsidies

As for its implication in both internal and external market dynamics, subsidies and income support schemes provided through CAP framework have a significant impact within the EU. Their main contributions relate to the economic sphere, as they play (and have played) a pivotal role in the production volumes, trade, and market dynamics, influencing the overall economic performance and outcomes of the agri-food sector. Even though the general aim of those policy instruments is to support and protect EU farmers and ensure a stable food supply, the allocation and distribution of subsidies can have unintended consequences, leading to both positive and negative economic externalities. These externalities encompass various aspects, including on the one hand market distortions, income disparities, competitiveness, resource allocation, and on the other incentives to rural jobs interindustry spillovers, effect on non-farm employment, environmental impacts, etc (Ciaian, Kancs, and Paloma 2015; Rizov, Davidova, and Bailey 2018; Schuh et al. 2016).

3.1.4.1.1 Economic impact

Subsidies and income support schemes have a significant impact on economic externalities, crosscutting several dimensions of the agri-food system. In line with their main goal, they have a direct impact on farmers' incomes, providing them with stability and support in an often-unpredictable market environment. As a consequence, they could play a pivotal role in **employment**, securing rural jobs, and contributing to the vitality of rural communities. But the effect could highly vary across regions and MS, and in some cases even generate additional negative economic externalities. A comprehensive report of 2016 commissioned by the European Parliament's Committee on Agriculture and Rural Development (COMAGRI) analyzed 53 studies to assess the impact of the Common Agricultural Policy (CAP) on rural job creation (Schuh et al., 2016).

The findings revealed varying perspectives on the direct effect of the CAP generally on employment in agriculture. Out of the studies reviewed, 16 reported a negative effect, indicating a potential decline in agricultural jobs. Conversely, nine studies indicated a positive effect, suggesting a potential increase in employment opportunities in the agricultural sector. Eight studies highlighted mixed effects, with outcomes dependent on farm structure and the broader rural economy, while six studies found no significant effect.

Additionally, the support offered by CAP subsidies can have indirect effects on off-farm employments of farmers, as could provide assets allowing them to invest in new technologies, and enhance their competitiveness, ultimately stimulating employment opportunities in related sectors. Also, in this case a high degree of heterogeneity characterizes the EU context.
From a **value chain** point of view, the infusion of direct payments into the agricultural sector could mean benefit (or loss) on both input and output markets. Firstly, they have the potential to raise input prices, such as those for fertilizers, land, and capital, which can benefit input suppliers in the agricultural sector. Secondly, subsidies may result in lower output prices, providing consumers with policy gains through more affordable agricultural products (Goodwin & Ortalo-Magné, 1992; Kilian et al., 2012; Weersink et al., 1999). The reason behind is that subsidies and income support schemes under pillar I are linked to a specific input use (for example, land) or output produced, and thus stimulate farms' demand on input markets and higher supply of production on output markets. Both effects have a detrimental impact on farm income, as stronger input demand increases input prices, while higher availability of supply on the output market reduces their prices (Ciaian, Kancs, and Paloma 2015).

Lastly, the effect of CAP direct payments on **consumers** can be observed through changes in output demand elasticities. By providing income support to farmers and ensuring a stable food supply, CAP subsidies can help moderate price fluctuations and maintain affordable food prices for consumers.

3.1.4.1.2 Environmental impact

programming period aimed to address environmental externalities associated with agricultural practices. An assessment provided included in the volume 'The Economics of regulation in Agriculture: compliance with public and private standards' (Hart et al., 2012) underlines the positive effects cross-compliance by promoting sustainable farming practices and addressing environmental challenges such as soil erosion, biodiversity loss, and water pollution. By imposing statutory management requirements, cross compliance encourages farmers to adopt environmentally friendly practices. However, there are also negative effects to consider. But the authors also underline that cross-compliance standards can be burdensome and may not always lead to significant environmental improvements. Additionally, the rigid nature of cross compliance may not adequately address region-specific environmental issues. Nevertheless, efforts are ongoing to enhance its effectiveness in achieving positive environmental outcomes within the CAP framework. The authors also underline some substantial limitations in assessing the impacts of such measures, including the lack of comprehensive data on the implementation and enforcement of cross-compliance requirements, as well as the difficulty in attributing specific environmental outcomes solely to cross-compliance. These challenges hinder the accurate assessment of the effectiveness and environmental impacts of cross-compliance in achieving the desired policy objectives.

The new CAP programming period 2023-2027 has introduced a new measure, the eco-schemes. They have a broader objective of promoting agricultural practices that contribute to environmental and climate goals. Unlike the greening measures, the participation in eco-schemes is voluntary for farmers. They provide financial incentives to farmers who voluntarily adopt specific agri-environmental practices that go beyond the basic requirements of greening. The eco-schemes offer more flexibility and customization options compared to the standardized greening measures, trespassing some of the limits identified for the previous programming period and previous measures. As for their recent implementation, an assessment of their environmental performance in internalizing environmental externalities is not yet available in both academic and grey literature, yet some studies assess the challenges and trade-offs with which national policy designers have to contend in devising national eco-schemes for agriculture (Birkenstock & Röder, 2019; Latacz-Lohmann et al., 2022).

3.1.4.2 Voluntary schemes and financial incentives

3.1.4.2.1 Environmental impact

The Agricultural Environmental and Climate Measures (AECM), along being the main policy instrument under the second pillar, have been charged with most of the environmental objectives of the CAP. These measures are designed to mitigate and reduce the negative effects of agriculture on the environment, promote sustainable land management, and protect natural resources. By implementing various practices and techniques, such as soil conservation, water management, biodiversity preservation, and agri-environmental infrastructure development, the AEM seeks to promote a more environmentally friendly. Yet, (Farmer et al., 2008) emphasized the urgent need for approaches that specifically address the spatial correlation between the uptake of AECM and environmental indicators at large spatial scales, to elucidate the impact of agri-environmental payments on ecological targets (Früh-Müller et al., 2019). During the last decades, various researchers have raised an interest in the extent to which AECM enhance environmental quality and ecosystem functioning has increased strongly in recent years (Giovanopoulou et al., 2011; Kleijn & Sutherland, 2003; Scheper et al., 2013;

Whittingham, 2011). Those same authors (Kleijn & Sutherland, 2003; Schmidtner et al., 2012; Zimmermann & Britz, 2016) have, in some cases, underlined a negative correlation between AECM payment and environmental impact indicators. Another recurrent criticism relates to the lack of rigor in the conditions under which the payments are made within the AECM schemes (Kleijn et al., 2004; Pe’er et al., 2014; Prager & Nagel, 2008).

However, assessments of the ecological consequences of specific AECM are generally confined to selected regions (Raggi et al., 2015; Uthes & Matzdorf, 2013).
This regional focus in the evaluation process may hinder a comprehensive understanding of the broader impacts of AECM across different agricultural contexts within the European Union (EU). Such a comprehensive assessment is, to our knowledge, far from being compiled. This also relates to the lack of robust and coherent evaluation framework. The CAP regulatory framework relies on CAP Common Monitoring & Evaluation Framework (CMEF) to assess its environmental objectives, and the effectiveness of the implementation of its policy instruments (e.g. AECM) to achieve them. However, the impact indicators of the CMEF primarily focus on measuring changes in specific components of natural capital, such as soil carbon content, nitrates concentration in groundwater, and farmland biodiversity. Unfortunately, these indicators do not directly capture the broader effects of these changes on ecosystems and the services they provide, such as the soil's contribution to biomass production or crop pollination (Pe’er et al., 2014). To address this limitation, Member States have the option to complement CMEF indicators with national indicators; however, this approach is often hindered by insufficient data availability. Consequently, many evaluations rely on proxy indicators, such as land use patterns and farming practices, as indicators of environmental effects (Dupraz & Guyomard, 2019; Primdahl et al., 2003). These proxy indicators are assumed to reflect a cause-effect relationship with the environmental objectives of AECM. However, research by suggests that such assumptions are often not supported by scientific evidence.

3.1.4.2.2 Economic impact

In areas where the implementation of AECM has generated positive environmental impacts (such as enhanced soil fertility, reduced pollution, and better water management), some second positive loop could also take place, as increased agricultural productivity, lower production costs, and improved farm profitability in the long run. Through the preservation of biodiversity and the provision of ecosystem services, some positive impact could be generated on tourism, recreational activities, and the overall quality of life in rural areas.

However, AECM may require changes in farming practices or the adoption of costly technologies, which can initially increase production costs for farmers. Additionally, AECM may impose compliance and administrative burdens on farmers, leading to additional costs in terms of time, paperwork, and potential penalties for non-compliance (Matzdorf and Lorenz 2010). These costs can be particularly challenging for small-scale and less financially resilient farms. Moreover, the implementation of AECM may lead to reduced agricultural production in some cases, potentially affecting the availability and affordability of certain agricultural products for consumers.

As scientific evidence on the effect of AECM and other voluntary schemes under the second pillar of the CAP is lacking, the information provided in the paragraph comes from internal knowledge (i.e. stakeholders' engagements, previous projects, partners).

3.1.4.3 Market support schemes

3.1.4.3.1 Economic impact

Market support schemes implemented under the Single Common Market Organization (CMO) Regulation (EU) 1308/2013 aim to strike a balance between market stability, income support for farmers, and fairer trading practices. However, it remains a complex and evolving framework with both positive and negative implications for the agricultural sector in the European Union. If on one hand they aimed at promoting market stability and the reduction of price volatility through the implementation of market management measures (e.g. public intervention, private storage aid, and withdrawal schemes), it is also true that they could lead to distortions in the market. Payments and subsidies under the CMO can create market inefficiencies, potentially leading to overproduction and excess supply. This can result in downward pressure on prices, affecting the competitiveness of certain agricultural sectors. Furthermore, unbalances across stakeholders of the value chain could occur, as for example farmers receiving a smaller share of the final consumer price, impacting their income and potentially leading to financial challenges for certain agricultural enterprises.

As scientific evidence on the effect of market support schemes of the CAP is lacking, the information provided in the paragraph comes from internal knowledge (i.e., stakeholders' engagements, previous projects, partners).

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3.1.4.4 Synthesis of EU CAP's impacts on social, environmental and economic factors

Table 19 provides a synthesis of the impacts of EU CAP and its instruments on social, environmental and economic externalities, as suggested by the literature review.

Table 19. Synthesis of reviewed positive (+), negative (-), and non-directional (/) impacts of EU CAP instruments on social, environmental and economic factors

	Social	Environmental	Economic
Income support & subsidies	(+) (-) (/)	(+) Promote sustainable farming practices (-) (/) Soil erosion (/) Biodiversity loss (/) Water pollution	(+) Farmers' income (+) Consumers' prices (decrease) (+) Rural jobs (-) Input prices (increase) (-) Rural jobs (/)
Voluntary schemes & financial incentives	(+) (-) (/)	(+) Promote sustainable farming practices (-) Promote sustainable farming practices (/)	(+) Production costs (decrease) (-) Penalties (-) Administrative burdens (-) Production costs (increase) (/)
Market support schemes	(+) (-) (/)	(+) (-) Overproduction (/)	(+) Reduced price volatility (-) Unbalance in value-added redistribution (-) Overproduction (/)

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4 Conclusion

Observations about the EU system:

The EU evaluation frameworks: An integral part of the EU policy cycle, defined also under the Better Regulation, is the phase of the policy evaluation, that should assess the effectiveness, efficiency, and impact of policies. Yet, it has been reported, under various policy frameworks analyzed within the report, that this phase often presents severe flaws. Just to mention: lack of robust indicators, problem in data collection, inadequate stakeholders' engagement.

Precautionary principle: Throughout its legislative history, the EU has adopted a robust precautionary approach to manage societal issues. In particular, in the wake of the mad cow food safety crises that hit the EU in the 1990s, the Union embarked on significant regulatory efforts to effectively address the issue and ensure robust precautionary measures for the future. It should be noted that at Member States' level, divergences in the sociocultural, political and environmental contexts might result in different application and interpretation of the precautionary principle.

Subsidiarity: The subsidiarity principle, which characterizes the EU political system, ensures, on the one hand, that decisions are made at the most appropriate level, allowing for more efficient and locally relevant policies, but, on the other hand, it can lead to fragmentated and inconsistent implementation, and a lack of uniformity in policy outcomes across Member States. Overall, this heterogeneity can result in varying economic, environmental and social impacts of EU regulations.

Territorial heterogeneity: Despite the harmonization efforts pursued in the last decades, the legislative context of the EU remains largely affected by strong territorial heterogeneities across Member States. This is partly due to the principle of subsidiarity, which leaves MSs to adopt the rules most relevant at decentralized level. This is also linked to the various degree of compliance with regulations.

Impact of European regulations on externalities:

- Overall, current legislation at EU-level consists essentially of **command-and-control** (regulatory) instruments, as opposed to market-based instruments. This might be due to the difficulty of establishing fair and effective market instruments such as taxing schemes at the level of the whole Union.
  These command-and-control regulations establish constraints on inputs or outputs to bring food production systems in line with more optimal levels, rather than directly targeting costs and/or prices in the systems.

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- The state of the EU nowadays suggests **little effect** of past regulations in improving global sustainability. Trends in the use and risks associated with pesticides and fertilizers and the state of fisheries, for instance, have not displayed satisfactory improvements in the last decades. The review suggests that the policy instruments under scrutiny in the present report have, at minimum, zero impact – or balancing positive effects in some territories and negative effects in others – and, in some worse cases, lead to negative impacts (ex. the Landing Obligation in the fisheries sector leading to illegal discards, thereby continuing fish stock depletion and causing false reporting and thus erroneous data for assessment). However, the lack of counterfactual situation precludes any comparison with the state the EU would be in today in the absence of these regulations.

- The low effectiveness of EU regulations in achieving sustainability objectives might be related to frequent issues of **implementation and compliance** within Member States. Stronger EU legislative efforts should be allocated to address that shortcoming.
  The strong heterogeneity across MSs' sociocultural, political and environmental contexts might be the source of divergences in the levels of compliance with uniform EU regulations. Differences in production or compliance costs, for instance, will create different incentives for each MSs to adopt a regulation.

- The low effectiveness of EU regulations in achieving sustainability objectives could also be linked to the targeted objectives themselves. The **economic interests** of major players in the systems seem to remain at the core of most EU regulations. This was observed in the thematic of fisheries, as well as for pesticide, fertilizers and animal welfare, which are associated with intensive farming systems. In these sectors, sustainability criteria are pushed behind and regulations fail to consider the integrated aspects of human health, animal health, and the environment.
  As noted by Libecap (2009), the party involved in decision-making – actual users of a resource, regulators, politicians – are generally not a residual claimant to the social gains from more optimal resource management and use. Accordingly, decisions tend to align with private returns rather than capture socioenvironmental returns for society as a whole.

- It should however be noted that the EU policy framework addresses very **complex issues**, such as food safety, transparent information sharing along value chains, and halting and reversing biodiversity losses. Reducing negative impacts and fostering positive behaviors in food systems to address these issues is

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therefore by definition an extremely difficult task. The heterogeneity of contexts encountered at MSs level further complicates the task.

- A common characteristic of all regulations is that they entail **implementation costs**. These costs, referred to as transaction costs, cover all direct and indirect costs that are to be made when it is decided to restrict or regulate an activity, including costs of implementation and of compliance.
  An issue frequently associated with command-and-control regulations is that they generate high compliance costs for the private sector. This is often mentioned as a cause for the lack of efficiency of such regulations. As a general observation, policies should always keep in mind that the costs of regulation ought to be lower than the welfare gains of internalizing the externalities. This however suggests that decision-makers should have information not only about socio-environmental costs and optimal levels to be attained, but also about the private production and compliance costs of users. This is a significant challenge for the implementation of effective policies.

- European legislation places a strong emphasis on the traceability of food products and on the provision of adequate and transparent information to consumers. Accordingly, food products are subject to strict **labelling** obligations. In addition to protecting consumers, these labelling requirements also protect the EU market by ensuring that products entering the EU meet certain socioenvironmental standards.

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Annexes

Annex 1. Overview of the instruments cited in this report and related policies

Instrument category		Thematic	Instrument Topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
							Socio	Envi
Command and Control	Ex-ante risk assessment	Fertilizers	Conformity	Regulation (EU) 2019/1009	Industry	Society at large	Food safety; Animal Welfare	Climate change; Acidification & eutrophication; Direct effects on biodiversity & ecosystems; Toxicity
		Pesticides	Approval of active substance	Regulation (EC) 1107/2009	Industries	Society at large	Food safety	Undissociated
		Pesticides	Approval of PPP	Regulation (EC) 1107/2009	Public authorities	Society at large	Food safety	Undissociated
		Pesticides	MRL establishment	Regulation (EC) 396/2005	Industries	Consumers	Food safety	
		GMO	GM crops, food and feed risk assessment	Directive 2001/18/EC; Regulation (EC) 1829/2003	Public authorities	Society at large	Human health; Animal health	Undissociated
		Animal helath & welfare	Approval processes for animal by-products and medication	Regulations (EC)1069/2009, (EU) 2019/4	Farmers; Industries	Consumers	Animal health; Food safety	Toxicity
	Market & post-market risk management	Fertilizers	Labelling	Regulation (EU) 2019/1009	Industry	Farmers	Consumers' rights	
		Pesticides		Regulation (EC)1107/2009	Industries	Farmers	User's right	

Instrument category		Thematic	Instrument Topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
							Socio	Envi
		Fisheries		Regulation (EU)1380/2013; Regulation (EU) 1379/2013	Fishing industry	Fisheries	Health; Consumer right	Undissociated
		GMO	Traceability and labelling	Regulation (EC)1829/2003; Regulation (EC)1830/2003; Regulation (EC)1946/2003	Industries; Farmer	Consumer	Consumer right	
		Animal helath & welfare		Regulations (EC)1069/2009, (EU)2019/4, (EU)2019/6	Farmers; Industries; Public authorities	Consumers	Consumer rights; Food safety	
		Pesticides	MRL controls	Regulation (EC)396/2005	Public authorities	Consumers	Food safety	
		GMO	Monitoring & Surveillance	Directive 2001/18/EC; Regulation (EC) 1829/2003	Industries; Farmers	Society at large	Human health; Animal health	Undissociated
		Fisheries	Catch certification scheme (imports)	Regulation (EU)1380/2013; Regulation (EC) 1005/2008	Fishing industry	Fisheries	Transparency	Undissociated
		Fisheries	Controls (EU activities)	Regulation (EC) 1224/2009	Fishing industry	Fisheries		Effects on biodiversity & ecosystems
		Animal helath & welfare	Placing on the market and use of	Regulation (EC)1069/2009	Farmers; Industries	Consumers	Food safety	

Instrument category		Thematic	Instrument Topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
							Socio	Envi
			animal by-products					
		Animal helath & welfare	Manufacture, storage, transport, placing on the market, prescription and use and disposal of medicated feed	Regulation (EU)2019/4	Farmers; Industries	Consumers	Animal health; Food safety	Toxicity
		Animal helath & welfare	Marketing authorization, supply, use and disposal of veterinary medicinal products	Regulation (EU) 2019/6	Industries	Consumers	Animal health; Food safety	Toxicity
		Animal helath & welfare	Controls and surveillance	Regulations (EU) 2016/429, (EU)1375/2015, (EC)2160/2003, (EC) 1/2005, (EU) 2019/6, (EU) 2017/625, Directive 2003/99/EC	Public authorities Industries	Consumers	Animal health; Food safety	Toxicity

Instrument category		Thematic	Instrument Topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
							Socio	Envi
	Implementing tools	Fertilizers	Agricultural Practices & Action Programmes	Directive 91/676/EEC	Farmers	Society at large	Food safety; Animal Welfare	Climate change; Acidification & eutrophication; Direct effects on biodiversity & ecosystems; Toxicity
		Pesticides	National Action Plan	Directive 2009/128/EC	Public authorities & Farmers	Society at large	Food safety	Undissociated
		Fisheries	Landing obligations	Regulation (EU) 1380/2013	Fishing industry	Fisheries		Effects on biodiversity & ecosystems
		Fisheries	Technical measures (Minimum fish sizes, fishing gear, etc.)	Regulation (EU) 380/2013; Regulation (EU) 2019/1241	Fishing industry	Fisheries		Effects on biodiversity & ecosystems
			Transport of live animal	Regulation (EC)1/2005	Farmers; Industries	Animals	Animal health	
Market support		Fisheries	Quotas	Regulation (EU) 1380/2013	Fishing industry	Fisheries		Effect on biodiversity & ecosystem
		Fisheries	Fisheries subsidies	Regulation (EU)1380/2013; Regulation (EU) 508/2014 ; Regulation (EU) 2021/1139	Fishing industry	Fisheries	Undissociated	Undissociated
		CAP	Income support & subsidies	Regulation (EU) 1307/2013	Farmers	Farmers & Society at large	Farmers living standards	Climate change; Biodiversity loss; Soil destruction

Instrument category		Thematic	Instrument Topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
							Socio	Envi
		CAP	Voluntary schemes & financial incentives	Regulation (EU) 1305/2013	Farmers	Society at large	Rural development challenges	Climate change; Biodiversity loss; Soil destruction
		CAP	Market support schemes	Regulation (EU) 1308/2013	Farmers & Agro-industry	Society at large	Market stability and price volatility	

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I. INTRODUCTION

The food sector plays a pivotal role in Romania's economy, serving as a vital component of national development and contributing to the well-being of its population. With its rich agricultural heritage and abundant natural resources, Romania has a significant agricultural potential – in 2020, approximately 32% of the EU's agricultural holdings came from Romania (Eurostat, 2022). This potential, however, comes with various challenges and opportunities that require careful consideration and strategic planning. In this context, effective food policies become crucial to ensure a sustainable, secure, and inclusive food system (Aceleanu, 2015).

The purpose of this report is to provide an overview of the food sector and food policies in Romania, that influence the integration of agriculture's externalities. By examining the current state of the sector and exploring the policies and initiatives in place, we aim to gain insights into the efforts being made to enhance the food sector's performance and address emerging issues.

As part of the FOODCoST project, through a comprehensive analysis of food policies, we will explore their role in promoting sustainable agricultural practices, ensuring food safety and quality, protecting public health, fostering rural development, and contributing to economic growth – in other words, that aim to integrate the externalities of the food chain.

By examining the interplay between the food sector and food policies in Romania, we seek to understand the impact of these policies on various stakeholders, including farmers, consumers, and the environment.

Overall, this report aims to provide a comprehensive and insightful examination of the food sector and the national-based food policies in Romania that directly affect the integration of agriculture's externalities. By delving into the opportunities and challenges faced by the sector, as well as the initiatives in place to address them, we can better understand the current state of the food system and identify potential strategies for its future development.

II. CHEMICAL SAFETY & BIOSAFETY

2.1. FOOD SAFETY

2.1.1. Introduction

Food safety is of utmost importance, as it plays a critical role in protecting public health, ensuring consumer confidence, and supporting the overall well-being of its population. Moreover, food safety has economic implications at various levels. For businesses, ensuring food safety can enhance their market competitiveness, build consumer trust, and contribute to long-term success. At the national or international level, a strong food safety reputation can improve export opportunities, support economic growth, and enhance trade relationships. Conversely, food safety incidents can lead to significant economic losses, trade restrictions, and damaged reputations (Hussain & Dawson, 2013).

On the governmental side, having a practical understanding of the food security situation is most likely to play a role in shaping the reforms aimed at enhancing the sustainability of the agricultural sector. This significance arises also from the need to align with the requirements of the European agricultural model and to adapt to the extensive integration and globalization processes in markets and agricultural production. According to research, key element in achieving food safety goals lies in sustainable agricultural production at the local community level, as they possess the knowledge and ability to effectively utilize agricultural resources (Drăgoi, et al., 2018). Consequently, it is crucial to systematically plan the security of the food supply, ensuring the viability of all components of the agricultural sector and, most importantly, the sustainability of agricultural production through internalizing the externalities within the food chain.

2.1.2. Description of the policy

In the case of Romania, according to the commitments made during the negotiation process and with the aim of approaching food safety in a unified manner, legislative initiatives were launched to promote and adopt a legislative document that aligns with the European model (Galatchi & Mihalache, 2010). An effective interpretation of legislation and practical approach can be found in ISO 22000, which emphasizes that hygienic and organizational requirements are manifested through Prerequisite Programmes (PRP's) and Operational Prerequisite Programmes (PRP's) (ISO 22000:2005, Food safety management systems and/or the framework that ensures a healthy diet for pupils in schools) (Brînzan & Țigan, 2010). In recent years, some companies in Romania have begun certifying their food safety management systems according to ISO 22000, IFS, or BRC standards, all of which incorporate the HACCP study (Hazard Analysis Critical Control Points), a common element in food safety standards (Chira, et al., 2013).

With regard to national policies in the field of food safety, Romania integrated the following (Table 2.1):

Table 2.1.

National-based food safety policies in Romania

Policy	Scope	Externality
Law no. 150/2004	This law sets the structure that every food and feed should be produced on. It aims at resulting in consumption-safe food and feed, which comes from respecting the hygiene and traceability standards.	Social – Namely, this law is meant to set the limits for using harmful ingredients or inappropriate techniques.
Order no. 1563/2008	This order includes a list of a foods that are prohibited from being sold and served within schools or nearby.	Social - The policy ensures a healthy diet for pupils in schools.
Order no.1898/2015	This order is about the constitution of a phytosanitary control body, aimed at the plant protection producers.	Environmental - This policy allows for the creation of a controlling body for the use of pesticides and other hard chemicals in agriculture.
Order no. 4634/2022	This order sets a new added-value tax for fertilizers and pesticides commonly used in agricultural production, seeds, and other agricultural products intended for sowing or planting, as well as for the provision of services typically used in agricultural production.	Economic – This order aims the taxation of products and services in agriculture.

2.1.3. Mechanisms of the instrument for internalization

1) Order no. 42/2004

This instrument represents an administrative-based regulation that aims to set conditions of commercializing food and feed. According to the order, food should only be commercialized if (Portal Legislativ, 2004):

a) It is not safe. Food is considered unsafe if it is harmful to health or unfit for human consumption. To determine if a food is unsafe, the normal conditions of food use by consumers at each stage of production, processing, and distribution should be taken into account, as well as the information provided to the consumer, including labelling or other general information made available to the consumer regarding the avoidance of specific harmful health effects caused by a particular food or category of foods.
    - To determine if a food is harmful to health, not only the probable immediate and/or short-term and/or long-term effects of that food on the health of the person consuming it should be considered, but also the effects on future generations, possible cumulative toxic effects, and the particular sensitivity regarding the health of a specific category of consumers when the food is intended for that category of consumers.
    - To determine if a food is unfit for human consumption, consideration should be given to whether the food is unacceptable for human consumption according to its intended use, due to contamination caused by external factors or not, alteration, deterioration, or degradation.

b) In the case where an unsafe food is part of a lot, batch, or shipment of food of the same class or with the same description, it is presumed that all the food in that particular lot, batch, or shipment is also unsafe, unless, following a detailed assessment, there is no evidence indicating that the rest of the lot, batch, or shipment is unsafe.

c) Foods that comply with specific legislative provisions regulating food safety are considered not to pose a risk with regard to the aspects covered by the respective legislation.

d) The conformity of a food with specific applicable provisions will not prevent the Authority, together with other competent authorities in the field of food safety, when necessary, from taking appropriate measures to impose restrictions on its placing on the market or to request its withdrawal from the market if there are reasons to suspect that, despite such conformity, the food is unsafe.

2) Order no. 1563/2008

This instrument represents an administrative-based regulation that prohibits certain foods from being commercialized within or nearby schools. The list of prohibited foods includes (Autoritatea Națională pentru Protecția Consumatorilor, 2008):

- soft drinks,
- foods high in sugar (more than 15g of sugar per 100 g),
- fat (more than 20g of fat, including more than 5g of saturated fat and 1g of trans fat per 100g),
- salt (more than 1.5g per 100g).
- Further, soft drinks and high energy foods (more than 300Kcal per 100g) are also prohibited and drinking water must be accessible.

3) Order no.1898/2015

This instrument represents an administrative-based regulation that allows for a controlling body in the phytosanitary field in Romania. The main responsibility implied is the control of individuals or legal entities conducting activities with plant protection products or with plants, plant products, and other related objects.

4) Order no. 4634/2022

This instrument represents a market-based tax, in the form of an added-value tax applied to the delivery of fertilizers and pesticides, as well as to certain services typically used in agricultural production. According to this policy, the added-value tax was decreased from 19% to 9%. The list of affected agricultural services includes various activities involved in crop production, livestock farming, and land improvement. It covers tasks such as fertilizing, plowing, harrowing, and preparing seedbeds. Sowing, planting, and transplanting are important steps for establishing crops, while spraying, dusting, and treating seeds help protect them from diseases, pests, and weeds. Harvesting, uprooting, and collecting baling plant material are related to crop harvesting and storage. Other activities include hoeing crops, levelling land, and constructing furrows for soil shaping. The list also encompasses tasks specific to livestock farming, such as sheep shearing, hoof trimming, and egg sorting. In vineyards and orchards, tasks like pruning, installing support systems, and irrigation/fertigation systems are essential. Land improvement works, genetic quality determination, and artificial insemination are also included.

2.1.4. Policy impact

According to Petrescu et al. (2018), Romanian consumers frequently pay attention to expiration dates and prices on food labels, but they tend to overlook nutrition information. These findings can be attributed to various factors. First and foremost, research found out that there is a strong emphasis on freshness and quality when it comes to food in Romanian consuming behaviour (Fleșeriu, et al., 2020). Consumers prioritize ensuring that the products they purchase have not expired and are safe to consume. Price is also an important consideration, as many consumers are price-conscious and seek affordable options (Bobe, et al., 2019). On the other hand, Tarcea et al. (2016) suggest that there may be a lack of awareness and education regarding the importance of nutrition information among Romanian consumers. The significance of understanding nutritional content, such as calorie intake, macronutrients, and dietary fibre intake, may not be widely communicated or emphasized in the general population.

Moreover, in a study by Drăgoi et al. (2018), a statistically significant relationship was found between climate change, weather conditions, and the occurrence of food-borne diseases in Romania. In stark contrast, Salmen et al. (2021) discovered that Romanian consumers possess greater awareness than the previous 10 years regarding environmental and ecological issues, the importance of consuming bioproducts, and the connection between food and health. However, the nutritional aspect of food labelling is not utilized effectively, and there is a prevailing lack of trust in food safety.

2.2. GMO

2.2.1. Introduction

Research suggests Romania has had a mixed history with genetically modified organisms (GMOs). Badea (2009) reports that Romania was an early adopter of GM crops, with Roundup Ready soybean and Superior New Leaf potato being approved for market release in 2000. Since Romania's accession to the European Union in 2007, the cultivation of Roundup

Ready soybeans has been prohibited, and the only genetically modified (GM) crop approved for cultivation in the EU is Bt-maize, which produces the insecticidal protein Cry1Ab from Bacillus thuringiensis (Bt). However, according to Ichim (2008) the commercial cultivation of transgenic plants in Romania has experienced a decline in recent years, as farmers await the availability of more profitable GM crops that better suit their needs. Antofie & Sand-Sava (2022) report that before 2007 Romania was considered a "Mega Biotech Country," with 87,500 hectares of GM soybean cultivation, but after joining the EU, Romania ceased the cultivation of any GM crops. Compared to other emerging technologies, particularly those involving renewable energy, Nistor (2013) reports that Romanians tend to view biotechnology with less optimism. Consequently, Romania has adopted a cautious stance towards the cultivation and use of Genetically Modified Organisms (GMOs), imposing restrictions on the cultivation of genetically modified crops, and currently, no commercially grown genetically modified crops are found in the country.

2.2.2. Description of the policy

The main national-based policy regarding the GMOs is Decision no. 173 of 9 February 2006 on traceability and labelling of genetically modified organisms and traceability of food and feed obtained from genetically modified organisms. In an externality acceptation, the obvious one that it focuses on is the social externality, with implications for human health and animal welfare.

This decision applies to all stages of market introduction of:

- Products consisting of genetically modified organisms or containing such organisms;
- Food produced from genetically modified organisms;
- Animal feed produced from genetically modified organisms.

2.2.3. Mechanisms of the instrument for internalization

The policy is an administrative-based instrument, since it states a regulation for the food market.

In the stage of market introduction of a product consisting of genetically modified organisms or containing such organisms, including in bulk, operators must ensure that the following information is transmitted in writing to the receiving operator:

- The product contains or consists of GMOs;

- The unique identification code(s) assigned to these GMOs.

Similarly, for products consisting of or containing GMOs, operators must ensure that:

- For pre-packaged products consisting of or containing GMOs, the label must include the statement "This product contains genetically modified organisms" or the statement "This product contains genetically modified [name of organism(s)]";
- For non-prepackaged products offered to the final consumer, the statement "This product contains genetically modified organisms" or the statement "This product contains genetically modified [name of organism(s)]" must appear on a sign accompanying the product display for sale.

When products derived from GMOs are introduced into the market, operators must ensure that the following information is transmitted:

- An indication for each of the food ingredients obtained from GMOs;
- In the case of products for which there is no ingredient list, an indication stating that the product is derived from GMOs.

The provisions of this policy do not apply to products containing traces of GMOs in a proportion of less than 0.9%, provided that these traces of GMOs are adventitious or technically unavoidable.

2.2.4. Policy impacts

The existing research provides insights into the status of genetically modified organisms (GMOs) in Romania. Roșculete et al. (2018) found that GMO soybean was present in some food and feed products on the Romanian market, with some samples exceeding the 0.9% limit. Curtis et al. (2007) found that Romanian consumers generally oppose GM food consumption, similar to consumers in Western Europe, and that negative risk perceptions of GM goods in Romania may make the implementation of these crops for economic development purposes difficult.

2.3. ORGANIC FARMING IN ROMANIA

2.3.1. Introduction

According to research papers, organic farming in Romania is an expanding industry that shows promise for future growth. Ion (2012) discovered that although the organic sector currently has a limited impact on the agri-food system, there is a notable increase in key indicators, indicating significant potential for further development. Popovici et al. (2021) identified regional disparities in the expansion of organic farming, with concentrated clusters of organic producers in livestock-oriented regions in central, north, and north-east Romania, as well as crop-oriented regions in the west, south, and south-east. The authors also observed a close correlation between the growth and spatial distribution of organic farming and supportive policies and European subsidies through the Common Agricultural Policy.

In 2009, Enache et al. (2009) projected a SWOT analysis of organic farming in Romania highlighting the strengths and weaknesses, the opportunities and threats that may help to promote well based and much more determined solutions on future development (figure 2.1), with most of the strengths referring to the environmental aspect of agriculture.

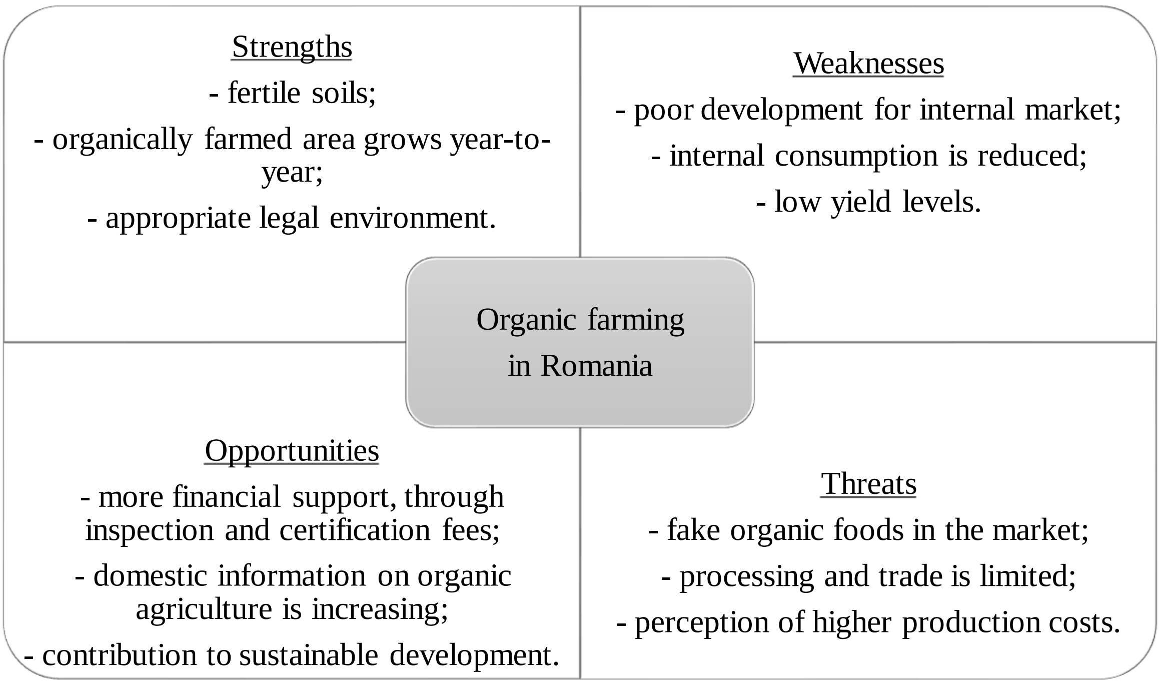

Figure 2.1. SWOT analysis on organic farming in Romania

Source: (Enache & Cârjilă, 2009)

In close relation to this, the literature indicates that organic food production and consumption in Romania are on the rise, yet there is still room for improvement. According to Răbonţu & Todoruț (2010), Romania possesses the potential to reach Germany's level of organic food production, but the demand from the population remains low. Vietoris, et al. (2016) discovered that Romanian consumers prefer purchasing organic food directly from producers and are willing to pay a premium of 5-10% compared to conventional food.

Furthermore, Dinu et al. (2014) observed an increasing consumer interest in "healthy" products, which could lead to a growth in the organic products market in Romania. Overall, the current research suggests that the organic food market in Romania holds potential for growth, but it requires enhanced education and awareness to stimulate demand among the population.

In 2021, Romania had close to 3.5% of the agricultural area as organically cultivated, with only cca. 579.000 ha (Eurostat, 2023). On a 9-year difference, though, the total organic area more than doubled – from cca. 289.000 ha in 2012.

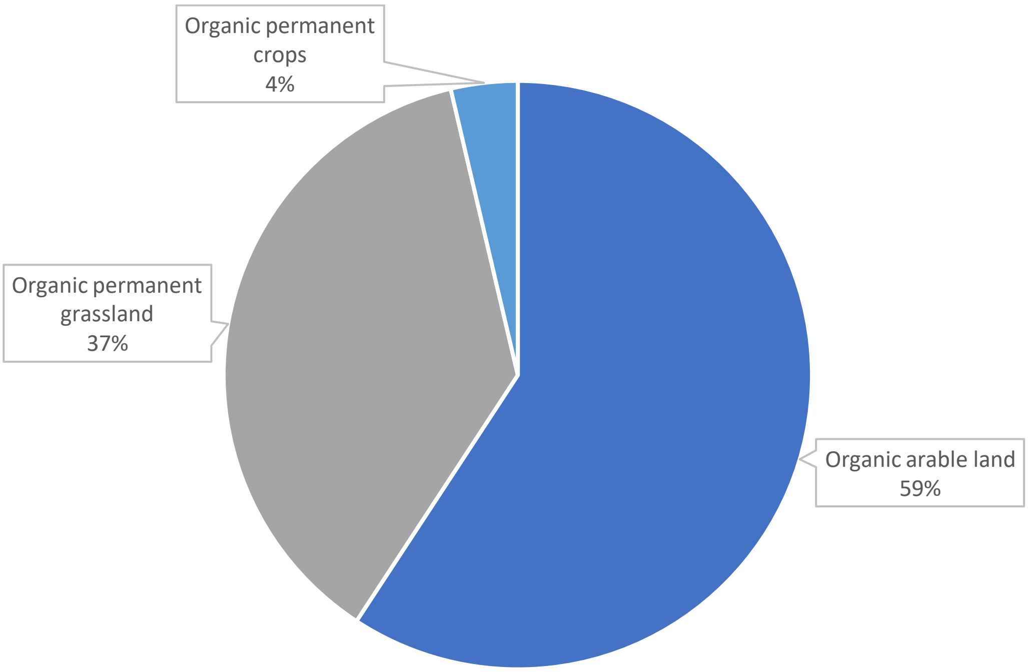

Figure 2.2. Share (estimated) of organic arable land crops, permanent grassland (pastures and meadows) and permanent crops in 2021

Source: (Eurostat, 2023)

In terms of organic livestock, Romania does not present high values, with only 1.4% and 1.3% shares in organic population of dairy cows and, respectively, live bovine animals. Meanwhile, Romania does not register organically grown swine population, whereas organic population of sheep and goats are found in only 0.12% cases in Romania (Eurostat, 2023).

2.3.2. Description of the policy

In Romania, EU regulations and other relevant regulations govern organic farming practices. The initial national legislation on organic farming, namely the Emergency Ordinance of the Government O.U.G nr. 34/2000, was introduced in 2000, followed by Law 38/2001 in 2001. This legislation remains current and aligns with EU Regulation (EC) No 834/2007. In order to be recognized as organic producers, individuals or organizations must obtain certification from one of the authorized control bodies. The Ministry of Agriculture and Rural Development holds the national logo for organic products, which can be utilized by products that adhere to the Romanian Organic legislation.

The national logo "ae" (Figure 2.3) and the EU organic logo are permitted to be displayed on labels of organic products. Producers, processors, and importers who have registered with the Ministry of Agriculture and Rural Development (MARD) are eligible to utilize the national logo "ae" on their products, labels, and packaging materials. Importers also have the option to use the EU organic logo; however, the label must specify the country of origin of the ingredients (EU or non-EU). For both logos, organic products must ensure that at least 95 percent of the ingredients are produced and distributed through organic methods (Ministerul Agriculturii și Dezvoltării Rurale, 2023). Labels of organic products should include the names of the producer/processor/trader and the name or code number of the inspection body responsible for overseeing and issuing the certificate for that specific organic operator.

Figure 2.3. Romanian organic agriculure logo

Source: (Ministerul Agriculturii și Dezvoltării Rurale, 2023)

In Romania, organic oversight and certification are carried out by private inspection and certification bodies that have been approved by the Ministry of Agriculture and Rural Development. These bodies conduct audits and inspections of organic operators, including producers, processors, and traders, at least once a year to ensure compliance with organic standards. The MARD website provides a list of approved organic certifying bodies involved in this process. Additionally, there is a separate list available that specifies the organic operators certified by each of the approved organic certification bodies. This allows for transparency and accessibility of information regarding the certification status of organic operators in Romania.

Complementing the EU policies regarding organic farming, Romania has also included a market-based instrument, through the Emergency Ordinance no. 31/2019 of 14 May 2019 regarding the granting of tax incentives. Through this regulation, the Romanian authorities stood by delimiting the foodstuffs coming from conventional agriculture and organic agriculture (as per the EU definition).

2.3.3. Mechanisms of the instrument for internalization

The Emergency Ordinance no. 31/2019 acts as a market-based incentive for the Romanian farmers and the general population as well, in order to tackle the economic externalities. It is applied to whole or processed agri-foods resulted from organic agriculture. This instrument is a compulsory one, meaning every organic agri-food producer is to respect it and the whole organic market is affected by it, since it is under the fiscal monitoring.

The instrument acts as an incentive, through decreasing the added-value tax of 9% from the conventional agri-food products to just 5% for the organic agri-food products. This is meant to balance the market price of organic products, thus increasing the chances for their consumption. First, the policy aims at lower taxation for a product originating from organic agriculture and, second, the final price as a result would be more competitive with a conventional product.

This policy is specific to a rather cross-cutting externalities approach, since it also approaches the social ones. The lower taxation for product originating from organic agriculture makes for greater chances that the population buy this category. In turn, a greater consumption of organic farming is related to greater health (Vietoris, et al., 2016).

2.3.4. Policy impacts

According to research, there is evidence that organic food policies have had an impact on the consumption of organic foods in Romania. Oroian et al. (2017) conducted a study and identified health concerns, sensory appeal, sustainable consumption, and weight concerns as the main reasons for consuming organic food products in Romania. Dumea (2012) and Romania (2012) investigated factors influencing the purchase decision of organic food consumers in Romania and found that environmental issues, concern about the nutritional value of food, and health issues were significant factors. Pop and Dabija (2013) observed an increasing number of Romanian retailers including organic food in their product range, and customers showed willingness to pay a premium for organic products.

III. NATURAL RESOURCE & ECOSYSTEM MANAGEMENT

3.1. QUALITY SCHEMES IN ROMANIA

3.1.1. Introduction

Traditional products had an important role for local identity, consumer behavior, preservation of cultural heritage. Quality policy, agricultural and special policies assure the promotion and protection of traditional products (Dragomir, Nicolae, & Dragomir, 2015). Among the benefits of traditional products consumption can be mentioned: access to fresh products, community development, and use of local resources. Traditional products have a significant contribution to the preservation of the biological and cultural diversity, improving all aspects of living (Nikolić, Uzunović, & Spaho, 2014). Consumers are more and more concerned about food safety and more interested in the origin of the raw materials (Răbonţu C. , 2010), and being more interested in the agri-food quality schemes. Likewise, consumers are more aware about the safety and quality measures during the production process (Mohd Nawi & Mohd Nasir, 2014). On the other hand, the consumers' preferences for convenience foods put pressure on all the actors from the value chain (Borda, et. al., 2021). The place of origin can add value to the traditional agri-food products (Guerrero, et al., 2009).

Romania recorded a progress in terms of the national food system. Based on the classification made by the Global Food Security Index 2022, Romania ranked the 45th place with a total score of 68.8 points out of 100, from a total number of 113 countries (Economist Impact, 2022). Romania is recognized on the European and international market for its reliable and trustworthy organic products (honey, cheese, and meat). Beside these Romania is making efforts to preserve and certify its national products (Stanciu, et al., 2019). However, one of the main market challenges of the traditional products can be that some of them are available just in some periods of the year (seasonality of raw materials) and are specific to areas they are produced, processed and, usually, prepared in small quantities (Teodoroiu, 2015).

3.1.2. Description of the policy and impacts

TRADITIONAL PRODUCT

The first regulation regarding the traditional products in Romania was in 2004, and until 2013 when new restrictions and regulations for certification were approved, there were over 4000 traditional products approved at the national level (Neculcea & Dona, 2023). After the implementation of Order (MADR) No. 724/2013 regarding the attestation of traditional products, in 2013 only 171 products received the certification of traditional products, from which by the end of 2022 just 24 were still certified.

According to the Order (MADR) 112/24.04.2020 on amending and supplementing the Order of the Minister of Agriculture and Development, the Minister of Health and the President of the National Authority for Consumer Protection no. 724 / 1.082 / 360/2013 regarding the attestation of traditional products, the traditional product is defined as a: “food product for which local raw materials are used, it does not contain food additives, has a traditional recipe, a traditional mode of production and / or processing and is distinguished from other similar products belonging to the same category”. This definition is similar to the one of Weichselbaum, et al., (2009) regarding the traditional products, which describes them as “food with a specific feature or features, which distinguishes it clearly from other similar products of the same category in terms of the use of ‘traditional ingredients’ (raw materials of primary products) or ‘traditional composition’ or ‘traditional type’ of production and/or processing method.”

Figure 3.1. Logo of the Romanian Traditional Product

Source: (Ministerul Agriculturii și Dezvoltării Rurale, 2023)

Traditional products are recorded in the National Register of Traditional Products (RNPT), established and administered by DGIA (National Direction for Food Industry), through the specialized department with responsibilities in the field of traditional products within the Ministry of Agriculture and Rural Development (MADR, Romanian acronym). In order to be included in RNPT the products must meet the following criteria:

- to be manufactured from local raw materials;

- to present a traditional recipe, specific to the place of processing, which reflects a traditional type of production and / or processing,
- to include in the stages of obtaining and processing the product operations performed manually and to prove a traditional way of manufacturing.

In order to be certified as a traditional product, it must be in accordance with a specification drawn up by the economic operator. In order to be certified as a traditional product, the product must meet the conditions in the specifications. The specifications must contain the following elements (Order MADR 112 / 24.04.2020, Article 6):

a) the name of the product. If the product is already registered under a custom, unique name, it is no longer eligible;
b) description of the characteristics of the traditional product, indicating:
    i. the main organoleptic properties: colour, taste, smell, aroma, consistency, appearance,
    ii. physicochemical properties: moisture, protein content, fats, carbohydrates, salt, pH, porosity and,
    iii. microbiological properties,
    iv. these main characteristics, depending on the case, are to define the product's traditionality / specificity.
c) description of the characteristics of raw materials, which should not contain additives obtained through chemical synthesis and others, such as food additives, flavors, vitamins, minerals; the origin of raw materials;
d) description of the characteristics of ingredients used in the manufacturing process, which should not contain food additives in their composition, except for natural additives such as colorants, flavors, vitamins, minerals, sweeteners; indication of the ingredients used and their main organoleptic, physicochemical, and microbiological properties, where applicable;
e) description of the specific local, authentic, and unchanging production method, as well as the description of the traditional technological process, where all production stages will be included, specifying the manually performed operations;

f) description of specific elements regarding packaging, aimed at ensuring quality, origin, and identification aspects, including the material from which the packaging is made, its properties, and its influence on the final product;
g) photograph and description of the product in section, where applicable, representing the specific characteristics of the product, its shape, and the production and/or processing method that reflects a traditional technological process through which the product distinguishes itself from other similar products belonging to the same category;
h) minimum requirements and procedures for verifying and controlling the traditional nature of the product;
i) the achieved production capacity - reported for one year, corresponding to 365 days - shall not exceed the average quantity of 150 kg/liters per day for the total of single-certified traditional product, and no more than 400 kg/liters per day for the total of certified traditional products, with the exception of traditional bread and bakery products, which cannot exceed the average quantity of 300 kg per day for the total of single-certified traditional product, and no more than 800 kg per day for the total of certified traditional products.;
j) data, inscriptions, and bibliographic references indicating the historical origin of the product, demonstrating the transmission of tradition from one generation to another, and establishing the historical connection of the traditional product with its place of production. Additionally, a declaration of notoriety from a local association of traditional product producers, signed by its governing bodies, may be included.

The labelling of traditional products must comply with the provisions of Regulation (EU) no.1169/2011 of the European Parliament and of the Council of October 25, 2011 regarding information to consumers regarding food products, amending Regulations (CE) no. 1924/2006 and (CE) no. 1925/2006 of the European Parliament and of the Council and repealing the Directive 87/250/EEC of the Commission, Directive 90/496/EEC of the Council, Directive 1999/10/EC of the Commission, Directive 2000/13/EC of the European Parliament and of the Council, Directives 2002/67/EC and 2008/5/EC of the Commission and Regulation

(EC) no. 608/2004 of the Commission. The label is completed with the logo and the position where the product was entered in the RNPT.

The Romanian market for traditional products has developed during the last decade, with 753 traditional products being certified in the present (Table 1).

Table 3.1.

Certification of traditional products

Type of product	No. of certified products
Beverages	35
Meat and meat products	307
Milk and dairy products	139
Vegetables/Fruits	120
Bread, bakery and pastry products	115
Fish	30
Other	7
Total	753

Source: (Ministerul Agriculturii și Dezvoltării Rurale, 2023)

ROMANIAN CONSECRATED RECIPE

A special category recognized at national level is that of products obtained using a well-established recipe. Joint Order MADR / MS / ANPC no. 394/290/89/2014 on the attestation of food products obtained according to Romanian Consecrated Recipes regulates the conditions that must be met by food business operators producing and selling food products, obtained according to Romanian Consecrated Recipes, for registration in the National Register of Consecrated Recipes (RNRC, Romanian acronym).

Figure 3.2. Logo of Romanian consecrated recipe

Source: (Ministerul Agriculturii și Dezvoltării Rurale, 2023)

Romanian Consecrated Recipe represents the Romanian food product that is obtained according to a recipe whose use has been proven to exist prior to the year 1975. In the process of registration, the Ministry of Agriculture and Rural Development (MADR) is responsible for the following measures:

1) entry of products obtained according to a prescription enshrined in the National Register (RNRC);
2) granting a certificate justifying that the product is obtained according to a well-known Romanian recipe;
3) management and transmission of the specific logo attesting to the way the products are obtained.

In order to verify the production units and the place of marketing of the products, representatives of MADR, ANPC (National Consumers Protection Authority) and MS (Ministry of Health) were empowered. In addition to the verification, they ensure that the products comply with the conditions and criteria underlying the granting of this certificate and logo attesting that the product is obtained in accordance with a well-known Romanian recipe.

By the end of 2022 in Romania, there were registered 23 consecrated recipes: 14 for meat products, 6 for dairy products, 3 for bread, bakery and pastry products. Furthermore, by June 2023 there are 58 certified products according to consecrated recipes: 30 from the meat category, 24 from the dairy category and 4 bread, bakery and pastry products (Ministerul Agriculturii și Dezvoltării Rurale, 2023).

MOUNTAIN PRODUCTS

Mountain food products are considered to have specific particularities and important for being representative to a certain region. It is claimed that a mountain product “offers high-quality foods as a consequence of the specific characteristics of the raw materials and also the traditional processing conditions” (Mihai, et al., 2022). Martins and Ferreira (2017) pointed out that dairy products and meat products have gain more attention due to their properties, which cannot be obtained in an industrialized way. The chemical and fatty acid compositions of the dairy products and meat products are influenced by the conditions in which animals are raised, the season, the feeding altitude, the biodiversity in botanical species, the grazing quality, the animal performances and genetics (Farruggia, et al., 2014, Caprioli, et al., 2020).

Mihai et al. (2022) conducted a research on 8 dairy products and 11 meat products collected from different mountainous pastures. The results pointed out that the fatty acid composition of mountain products was influenced by the pasture location. Products from farms on a higher altitude have a better content of polyunsaturated fatty acids.

The term "mountain product" quality highlights the specificity of a product, made in mountain areas, with difficult natural conditions conform to EU regulation 665/2014. This optional quality term is an advantage for both farmers and consumers because it allows farmers to promote the product better, but it also ensures that certain characteristics are clear to the consumer. This certification is granted for food and products of agricultural origin. The main specifications for them are that the raw materials and animal feed come from the mountain areas, while for the processed products the production should take place in such areas as well.

Figure 3.3. Logo of Romanian Mountain Product

Source: (Ministerul Agriculturii și Dezvoltării Rurale, 2023)

Nowadays, consumers are more concerned about the proprieties of the food products, how they are produced and the effect on their health (Howard, 2005). In this context, mountain food products are being attractive to the consumers due to their authenticity, uniqueness and reinforcement of the external image of a specific region (Euromontana, 2020). However an increase of the production may affect the quality of the product, while intensive grazing should be avoided in order to preserve the quality of grasslands and the subsequent quality of mountain foods (Martins & Ferreira, 2017). On the other hand by improving the demand of the mountain food products, the support for local farmers will be greater, to ensure economic development. Providing the proper framework, it allows the promotion of entrepreneurship, thus reducing the unemployment and migration of the young people from these areas. By promoting, protecting and certificating the mountain food products it might ensure the development and reduce the desertification of these areas (Martins & Ferreira, 2017).

Several EU Member States already implemented the "mountain product" optional quality scheme, or are in the process of implementation (Figure 3.4).

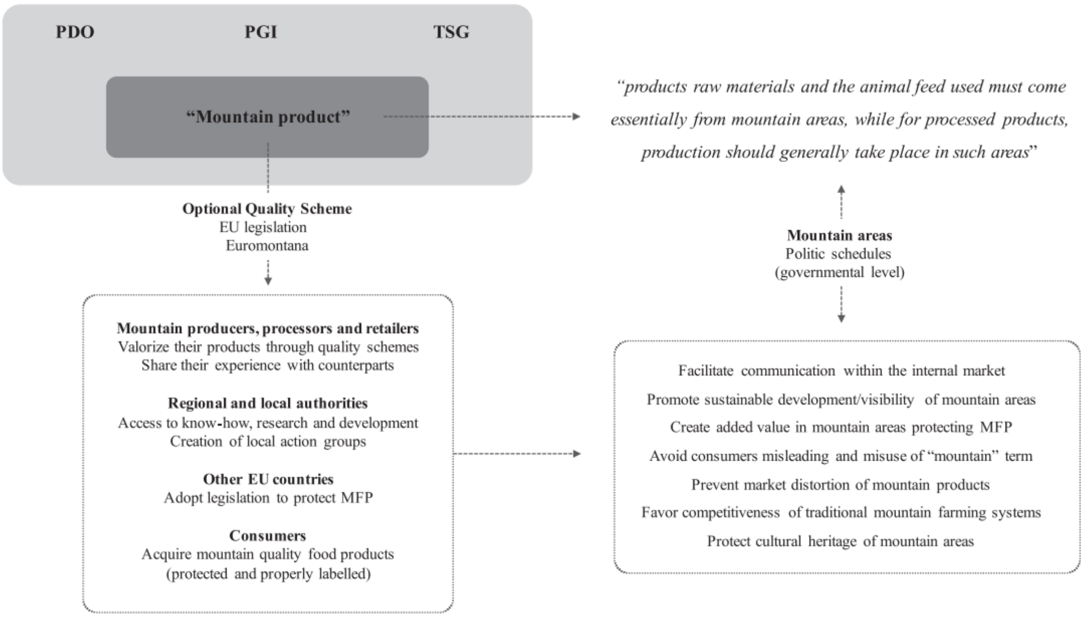

Figure 3.4. Conditions regarding the establishment of the optional quality scheme "mountain product"

Source: (Martins & Ferreira, 2017)

Figure 3.5. Implementation of the optional quality "Mountain Product" in 2020

Source: (Euromontana, 2020)

A comparative analysis was done by Euromontana (2020) among the countries that applied the “mountain product” certification (Table 2.2). The data revealed some particularities in the case of France and Italy, where specific brands of mountain products were already developed. At the same time in Italy the derogation on distance of processing was reduced to 10 km, while in Romania it is 30 km based on the Order 174/2021 of Ministry of Agriculture and Rural Development. Moreover, in the case of France, Slovenia and Italy there is no need for pre-authorization, like in the case of Romania, Czech Republic, Bulgaria, Croatia.

Table 3.2.

Comparative analysis of the optional quality term (OQT) "Mountain product"

Country	Adaptation process at national level	Derogation on distance of processing	Authorization	Control System against fraud	Examples
France	The ordinance 2015 - 1246 on signs for the indication of quality and origin – the French Ministry of Agriculture	None	No need of pre-authorization	DGCCRF at local level	– Mont Lait – Origine Montagne
Germany	The Food Specialties Act to the EU legislation in order to integrate the OQT into the federal legislation – the Federal Government, 2016	None	Regulation (EU) No 1151/2012 and Delegate Regulation (EU) No. 665/2014	Various authorities will be in charge at Bundesland level or local level.	
Italy	– "Regolamento communitario" -26 July 2017; – National guidelines on the controls - 20 July 2018, the National Decree	– 10 km derogation for the production of milk and milk products; – 30 km for the rest	Farmers have to notifiy the regional authorities	Regional level	– Latteria Sociale Valtellina – Latte di Chiuro
Romania	– Decision no. 506/2016 that defined the institutional	The only derogation is for the production of milk	Romania has chosen to ask farmers for a pre-authorisation	National Consumers	

	framework and measures for the implementation of the Regulation 665/2014; – Order No. 52/2017 – Ministry of Agriculture and Rural Development	and milk products; slaughtering of animales, cutting and deboning of carcasses - these may take place 30 km outside mountain areas	Mountain Area Agency, who is a part of the Ministry of Agriculture and Rural Development, is in charge of coordinating the implementation	Protection Authority	
Slovenia	– The Act of Agriculture (OJ No 26/14) – 2014; – The rules on quality schemes for agriculture products and foodstuffs (OJ No 23/15) - 2015	None	No need for pre-authorization, just to inform the ministry about it at the beginning of their commercialization	National Administration for Food Safety, Veterinary Sector and Plant Protection,	
Czech Republic	In 2011, the Czech Republic adapted its legislation to integrate OQT in general and, since 2014, has included “mountain products” as one of these OQTs.	None	Apply through the Ministry of Agriculture of Czech Republic	State Veterinary Administration – animal products Food Inspection Authority – plant-based products	

Bulgaria	The Ordinance No. 4/28.05.2019 on the conditions and procedure for the use of the optional quality term "mountain product" and for the control of its use - the Bulgarian Ministry of Agriculture, Food and Forestry	Slaughtering of animals and cutting and deboning of carcasses may take place outside mountain areas, provided that the distance from the mountain area in question does not exceed 30 km	Application to the Regional Food Safety Directorate. After documentation-analysis and on-the-spot check, the farmer will have to be registered in the public Register of the producers of OQT "mountain product"	Bulgarian Food Safety Agency	
Croatia	NN 38/2019 - national legislative measures for PDO, PGI and guaranteed traditional agricultural and food products and the optional quality term "mountain product"	30 km	Pre-authorization	The Ministry of agriculture, a food inspector, and an accreditation agency	

Source: (Euromontana, 2020)

Analyzing the number of the certified mountain products, it was noticed that by the end of March 2023, 1140 products were certified as a mountain product in Romania. From these 1140 products, 14 of them are also recognized as traditional products, 10 of them being from the category of vegetable/fruits products, 2 of them from milk and dairy products, and 2 from fish and fish products category. In comparison, in 2020 Euromontana reported 615 mountain products in Italy.

Tabel 3.3.

Analysis of the certified mountain products in Romania

Type of product	No. of certified mountain products
Bee products	222
Meat and meat products	28
Milk and dairy products	527
Vegetables/Fruits and vegetables/fruits products	609
Bread, bakery and pastry products	4
Fish and fish products	10
Eggs	10
Total	1140

Source: (Ministerul Agriculturii și Dezvoltării Rurale, 2023)

IV. FOOD SECURITY & NUTRITION

4.1. FOOD SECURITY

4.1.1. Introduction

Despite initial expectations of a swift recovery from the crisis and a restoration of food safety and security in the aftermath of the pandemic in 2021, the grip of the pandemic persisted and even tightened in certain regions of the world. While many countries experienced a rebound in gross domestic product (GDP) growth during the year, this positive economic trend did not immediately translate into improvements in the food sector, especially food security. The most vulnerable populations, including those with limited financial resources, unstable incomes, and inadequate access to essential services, continue to face significant challenges. The COVID-19 pandemic has exacerbated existing inequalities both between and within countries, and the ongoing economic recovery has yet to effectively reverse these disparities (Food and Agriculture Organization of the United Nations, 2022).

In the 2022 Global Food Security Index (GFSI), Europe achieved an average score of 74.8 for its overall food security environment, positioning it as the second most food-secure region worldwide. Among the four pillars of the index, the region attained the highest score on the Affordability pillar (87.2), indicating that food remains affordable for consumers. However, Europe obtained its lowest score on the Sustainability and Adaptation pillar (63.7), suggesting the need for further improvement in food production to mitigate short-term availability risks and long-term climate-related risks. Additionally, there is room for enhancing policy commitments on food security and access by governments, as well as protecting the region's oceans, lakes, and rivers.

Meanwhile, in the same GFSI 2022 record, Romania is ranked 45th out of 113 countries and 23rd out of 26 European countries. The country has an overall GFSI score of 68.8. Romania's highest score is in the Affordability pillar, where it scores 85.1, indicating good performance in providing affordable and high-quality food to the population, ensuring food security for consumers. Similarly to the whole European trend, Romania's weakest areas are in Sustainability and Adaptation, scoring 47.1. The country lacks adequate policies to address sustainability and adaptation issues, particularly in protecting its natural resources from climate change exposure, preventing overexploitation of marine biodiversity, and addressing the eutrophication of its seas, rivers, and lakes.

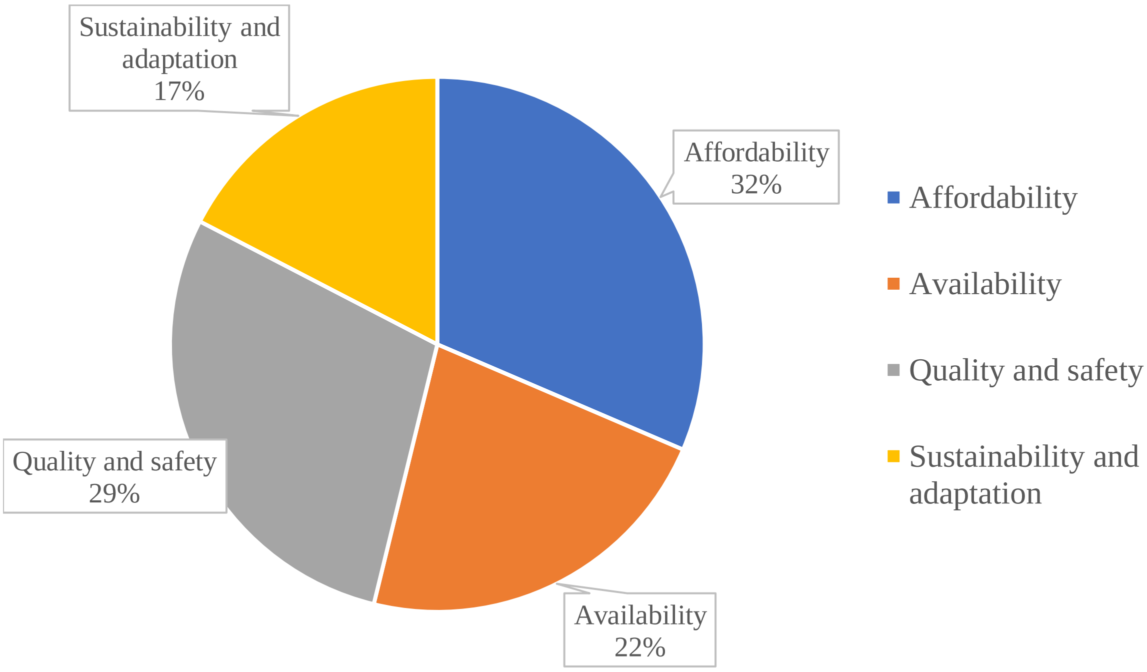

Figure 4.1. Share of the overall Food Security Environment score for Romania, 2022
Source: (Food and Agriculture Organization of the United Nations, 2022)

4.1.2. Description of the policy

According to the 2022 Global Food Security Index, within the Availability pillar the two subcategories that are evaluated as 'weak' are the volatility of agricultural production and food security and access policy commitments. This makes for a significant social externality regarding food security, especially towards vulnerable parts of the community.

However, one national recent policy aimed at mitigating the vulnerability of the food chain is the Emergency Ordinance no. 63 of 9 May 2022 on certain temporary measures for providing material support to categories of persons at risk of material deprivation and/or risk of extreme poverty, partly borne by non-reimbursable external funds, as well as certain measures for its distribution. This policy tries to tackle the social externality of food security – the living crisis that some parts of the population was faced with in the context of the 2022 inflation and pricing crisis.

4.1.3. Mechanisms of the instrument for internalization

This policy works as a market-based instrument. Clearly, it is a support scheme for the vulnerable Romanian customer. According to this order, the Romanian population included in the vulnerable category is to receive food vouchers in six installments, once every two months. Each voucher is worth RON250 (cca. EUR50) and can be used to purchase food as well as pay for hot meals at restaurants or other establishments where this service is available.

4.1.4. Policy impacts

There seems to be research insights into the food voucher system in Bulgaria and Romania, but none of them directly address the impact this system has. Voinea et al. (2019) and Voinea et al. (2020) examine the food behavior of Romanian consumers and suggest the need for supporting educational campaigns targeted at Romanian consumers aimed to develop healthy food habits that could contribute to the development of environmental sustainability. Alderman, Gentilini, & Yemtsov (2017) explore the integration of social protection and food assistance agendas, but does not provide any specific information on Romanian food vouchers.

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